A McGRAW-HILL PUBLICATION DECEMBER 1961

ONE DOLLAR

Power

the magazine of energy systems engineering

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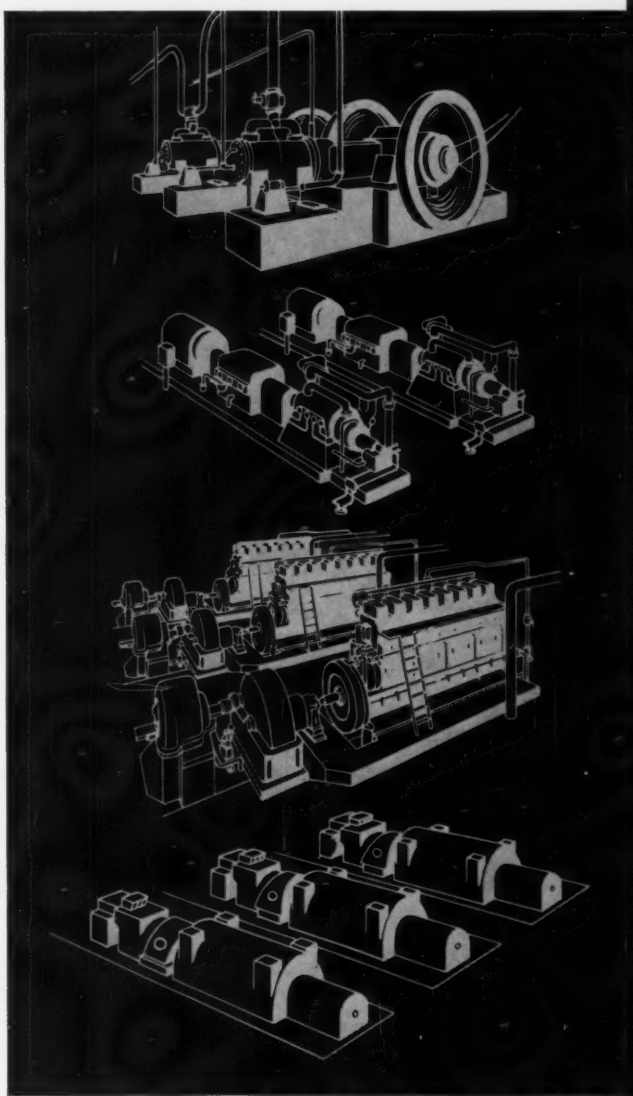

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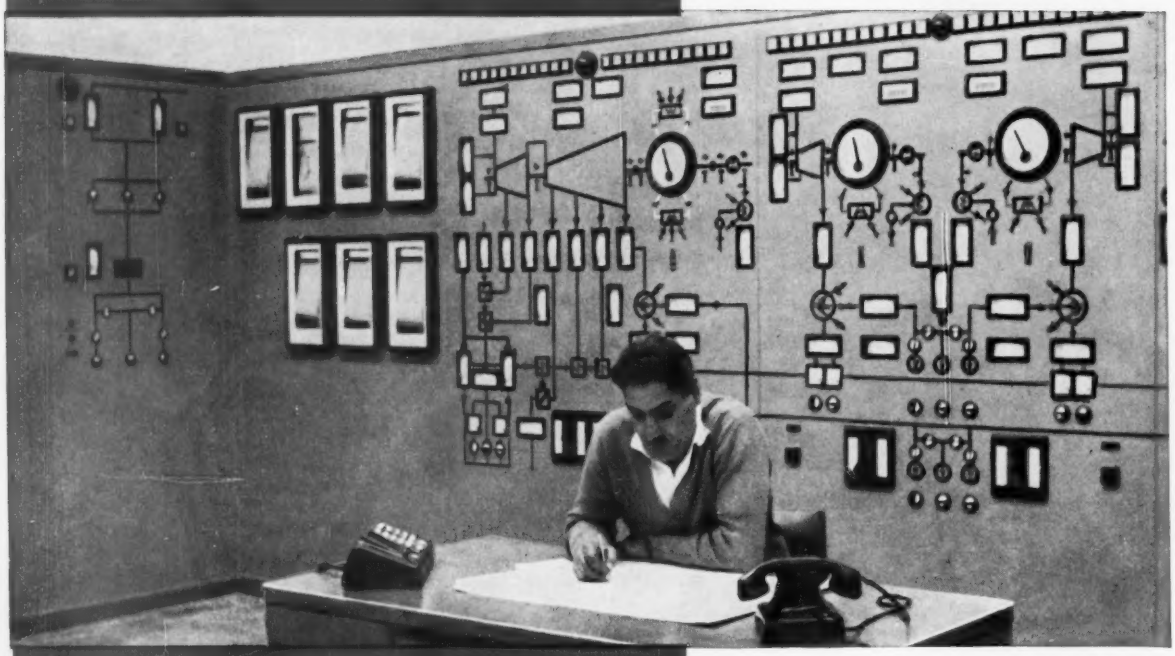
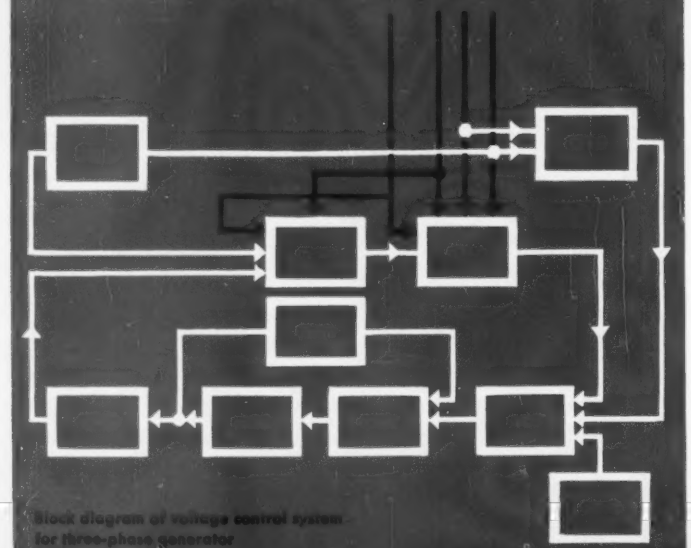
MEASURING REGULATION CONTROL



View of AEG thermal control board in a new steam power station



Block diagram of voltage control system for three-phase generator

If its Automation - consult

- Measuring instruments
- Precision instrument equipment
- Indicating instruments and recorders
- Electricity meters
- Machine-tool control equipment
- Remote control systems
- Photo-electric elements
- Industrial tubes
- Reactive power limiters
- Voltage regulators
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AEG

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ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT

Berlin (West) EXPORT DEPARTMENT Frankfurt (Main)

For more facts circle 201 on Reader Service card, p 117

TURBINES:

Shell reveals three ways that Turbo Oils help prevent oil breakdown, rust, sludge and foaming

Small quantities of air and water can work their way into any turbine lubrication system. These contaminants can accelerate oxidation of the oil.

Read how Shell scientists developed a specific formulation that counters this oxidation and brings you turbine lubricating oils with top performance records.

WHEN oxygen attacks turbine oil, it can form peroxides and organic acids. A chain of oxidation reactions begins. If the oil stability is inadequate, sludge can form.

Air entrained in the oil can aggravate oxidation. And it may cause foaming.

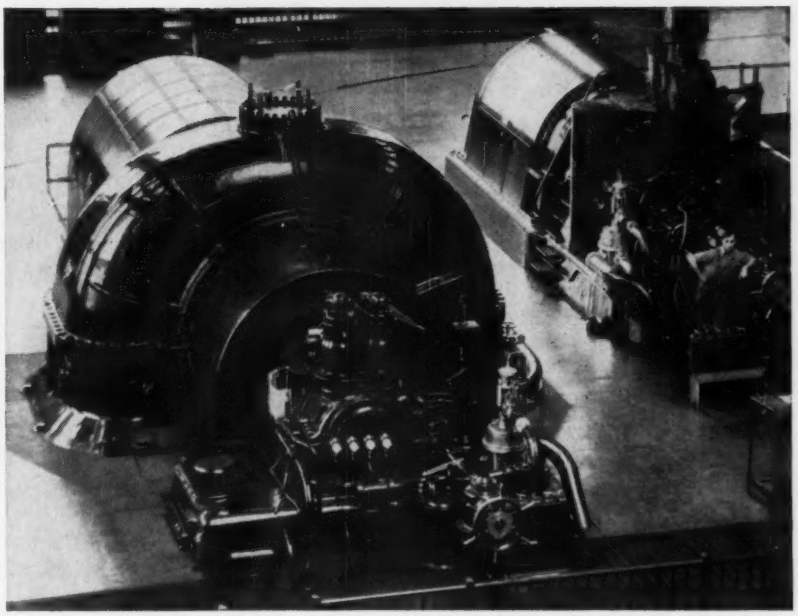
The oil may also be affected by water in the system. Laboratory tests have shown that water can greatly accelerate an oxidation process.

With Shell Turbo® Oil, Shell tackles these problems in three key ways:

1. *Shell carefully selects base oils for use as turbine lubricants,* then refines them to get the most effective response to Shell's special additives.

2. *Shell adds a powerful oxidation inhibitor to its precisely refined base oils.* This inhibitor helps prevent the chain of oxidation reactions caused by oxygen exposure at operating temperatures. It helps keep the oil in good condition, and lengthens its service life.

The result is that Shell Turbo Oils have proved themselves unusually stable over long service periods.



Shell Turbo Oils lubricate turbines with total rating of more than 17 million kw in the U. S. and Canada.

3. *Shell uses an outstanding rust inhibitor.* As a protective measure, Shell uses special additives that cover metallic surfaces with strongly adherent polar-type films.

These films are specially designed to help keep water from the metal surface.

In drastically accelerated laboratory tests, metals immersed in Shell Turbo Oils show outstanding anti-rust performance—even in the presence of sea water.

Ask your Shell Industrial Products Representative for facts on Shell Turbo Oils. Or write: Shell Oil Company, 50 West 50th Street, New York 20, New York.

Memo to utilities

Ten turbines in the U.S. have been running on Shell Turbo Oil 27 *since 1938.*

In Canada, Shell Turbo Oils lubricate turbines generating more than half of all steam power produced.

SHELL

A BULLETIN FROM SHELL

—where 1,997 scientists are working to provide better products for industry

For more facts circle 204 on Reader Service card, p 117

speaking of **Power**

"Chief" Bender and Bob Marks: fresh start on new challenges

Staff changes last month came in the form of a promotion to special projects editor for Bob Marks, a new job as associate editor for "Chief" Bender.

Bob Marks in his new position will guide our future staff reports through to a successful end. This means, among other things, working closely with staff editors during each stage of a major editorial project. Bob is well-qualified by training and temperament for his new responsibilities.

After graduating from MIT, Marks racked up more than 10 years of solid engineering experience, then topped it with four years of editorial know-how as a POWER editor. Plans call for Bob continuing his work in water, air conditioning and other fields.

René J Bender will fill the gap created when Lawson Stewart left to go with IBM. The "Chief's" major technical responsibility will be fuels and steam. And this is quite natural since years back, both in this country and abroad, he designed, constructed and tested pulverized-coal-fired installations. Bender was later connected with Sinclair Oil Corp for 25 years, as combustion engineer, then as manager of the fuel-oil department, as publisher of the *Sinclair Firebox*, as consulting engineer and finally

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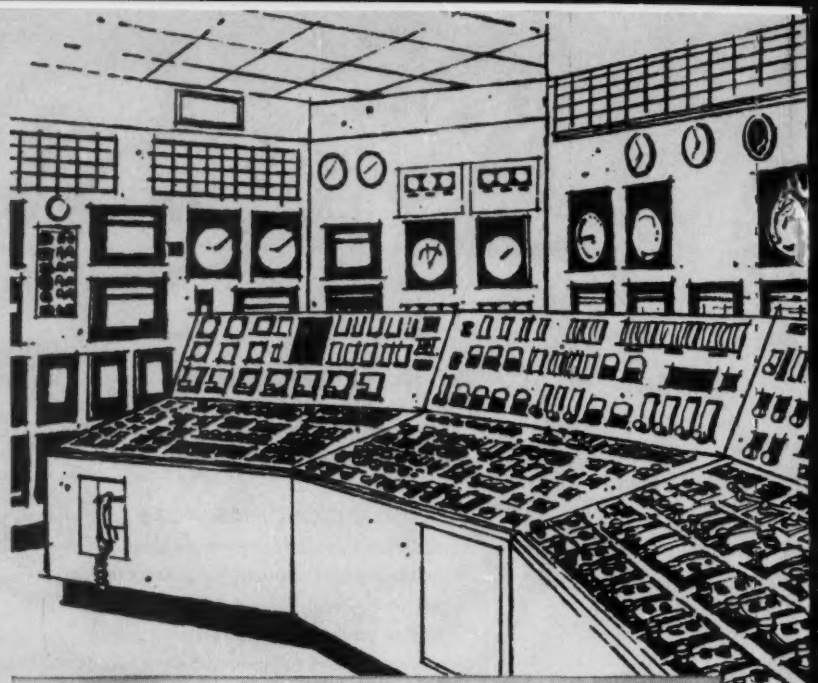


FIRST SIMPLIFY...

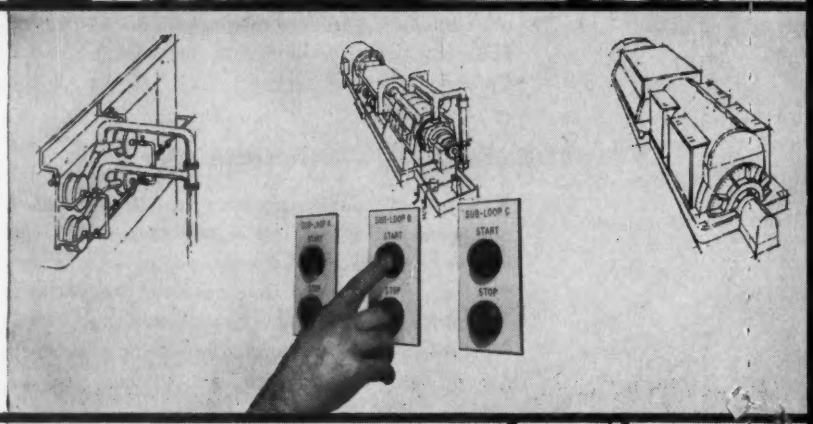
First step to automation is to *simplify* the information now presented by a multitude of multi-record charts, gages, and annunciator lights. The Bailey approach gives the operator data he needs (logged periodically), keeps continuous watch on all variables, makes calculations where required, alarms when trouble threatens.

Bailey 700 Systems draw on the best available techniques, including analog and digital manipulation, trend recording, time sharing, scanning, alarming, calculating, controlling, and logging, as required to meet operating objectives.

Reliability of recorded data is increased . . . operators can devote full attention to correcting off-normal conditions and improving operations. The system may include frequent performance calculations showing the contributions of each portion of the cycle to over-all performance so that faults and deterioration may be spotted and corrected.

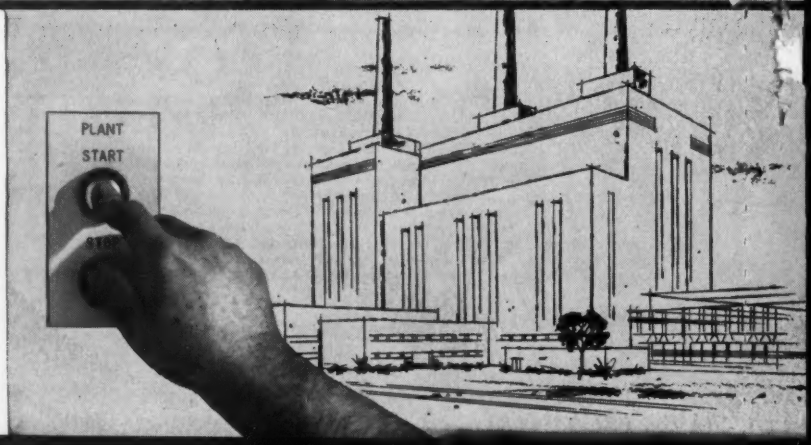
NEXT VERIFY...

Next verify the practicability of automation by extending supervisory controls, letting equipment perform more operating functions. Automate key systems, one at a time, by push-button-controlled subloops. This approach smooths the transition to complete automation.



THEN AUTOMATE

Final steps are: (1) consolidate supervisory controls, conventional controls, and subloops for full-range automatic operation once the plant has been placed on the line; and (2) add start-stop control to provide full automation.



first Simplify...

NEXT VERIFY...
THEN AUTOMATE

Bailey verified steps to automation mean benefits now... and increasing benefits as you go

Automation need not be an all-out commitment. Between today's conventional power-station control and the ultimate in automation are step-by-step advantages that can be gained—as individual problems are resolved.

This permits the final investment commitment only after satisfactory evidence that it is economically justified and practicable.

Bailey Systems concepts are embodied in the approach, "First simplify — next verify — then automate". The steps outlined here coordinate the best available techniques, including analog and digital, in Bailey 700 Systems designed — and expanded as desired — to the needs of the individual plant. They may be undertaken singly, in combination, or in entirety. System elements are composed of solid-state electronic modules providing the ultimate in reliability and flexibility.

Bailey 700 Systems are in operation today —or on order for installation—from coast to coast and all over the world. Ask your Bailey Engineer, or write for details. Bailey Meter Company, 1036 Ivanhoe Road, Cleveland 10, Ohio. In Canada — Bailey Meter Company Limited, Montreal.

System concepts founded on 45 years of experience

21 out of 26 of today's "most efficient" steam-electric stations in the United States use Bailey Instruments and Controls*. This reflects the more than 45 years of Bailey developments devoted to improving the reliability of power-plant operation. These developments include experience in automation, dating from electrically operated boiler controls in 1924 and automatic start of boiler controls on steam-electric locomotives in 1936, to systems installations in operation, or under construction today, from coast to coast and throughout the world.

**Listed in Federal Power Commission Report S-143.*

A 166-2

BAILEY METER COMPANY

700 Systems

For more facts circle 205 on Reader Service card, p 117

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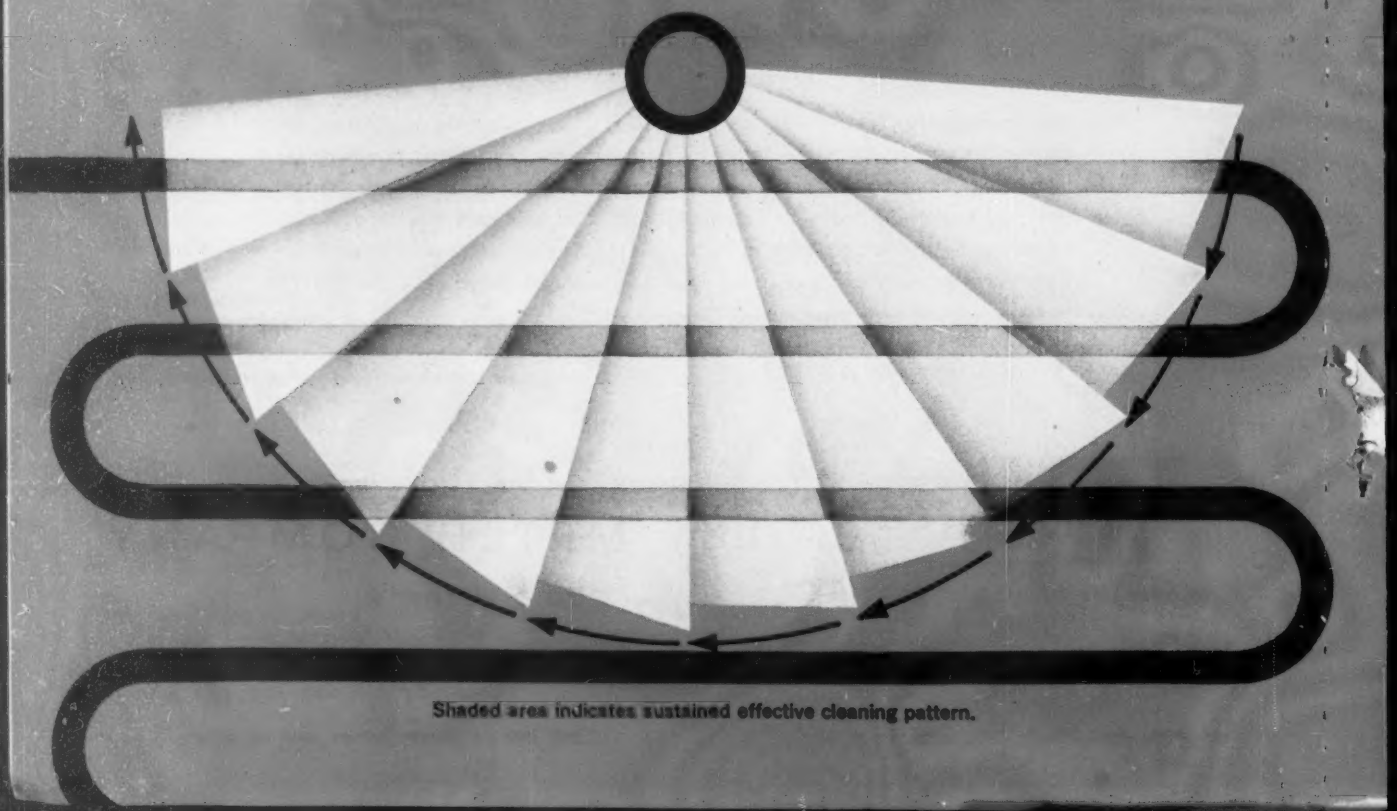
Diamond developed for more economical power...

AIR PUFF BLOWING=CLEANER BOILERS... AN APPRECIATIVE PUBLIC

THIS.....



Shaded area indicates sustained effective cleaning pattern.

Two of today's more critical conditions for efficient steam generation . . . clean boilers and acceptable stack emission . . . are assured with Diamond Air-Puff Soot Blowing Systems.

Increased cleaning efficiency is obtained because high density air is used as the cleaning medium and emitted in sustained high pressure puffs that are independent of receiver capacity or compressor size. Also, because no air is emitted at ineffective low pressures, there's greater economy in *use* of cleaning medium.

Acceptable stack emission is achieved because intermittent air puff blowing eliminates more concentrated and objectionable emission caused by continuous blowing arcs or blowing puffs of longer duration. In the standard Diamond Air-Puff System, intervals between air puffs are determined by the time required for build-up to optimum blowing pressure; however, if more positive control of stack emission is desired, intervals can be regulated by a simple valve adjustment.

The Diamond Air-Puff Blowing System for new *or* existing boilers of any type and capacity is further evidence of why "Diamond developed" means more economical power. Our engineers will be happy to discuss its application to your units. Call, write or wire for complete information . . . and thank you for reading our advertisement.

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This is the new trademark of Diamond Power . . . a symbol of quality, integrity and progress . . . in products, systems and service.

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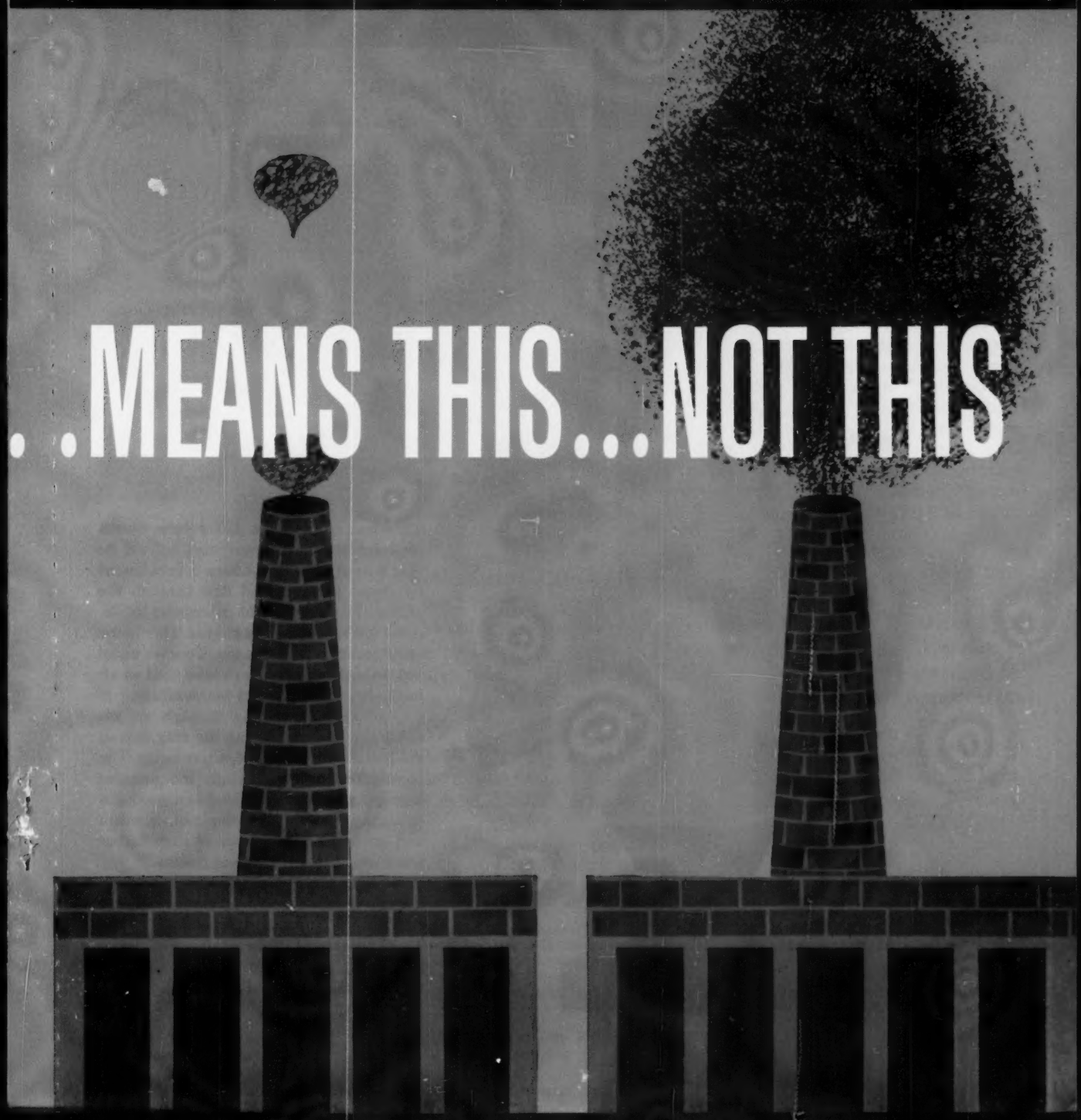
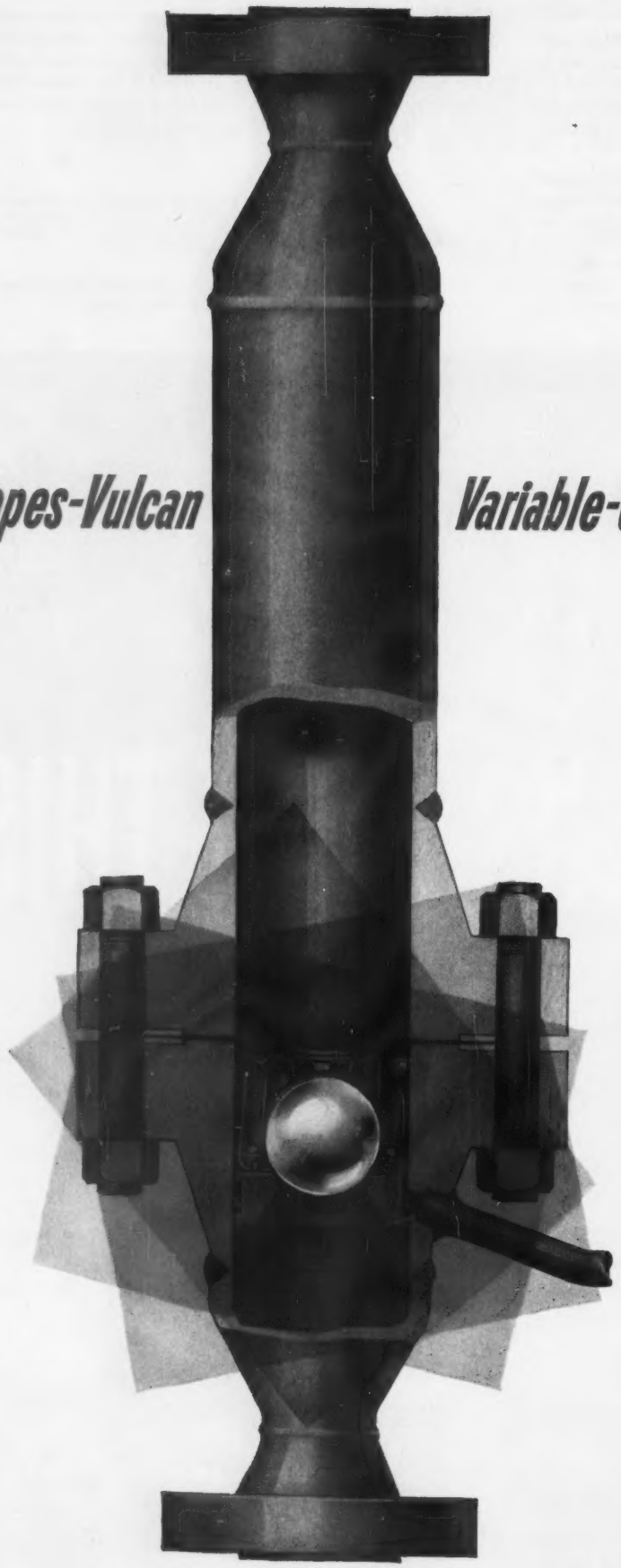


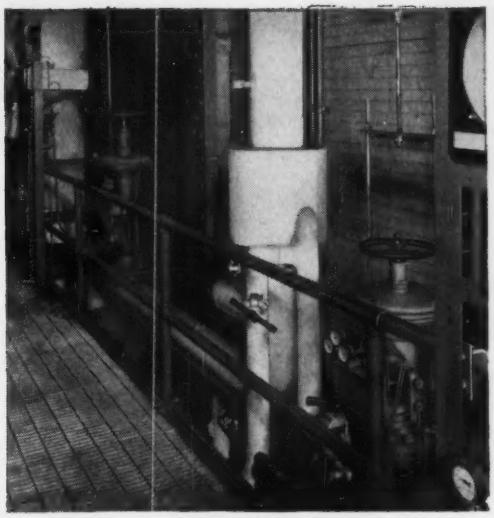
Copes-Vulcan Variable-Orifice desuperheater



This ball makes the difference. Steam pressure lifts a weighted steel ball off its ring seat to a position where it is balanced by steam pressure and flow through the orifice. The ball is held concentric by Inconel springs and rigid guides. This is the only moving part in the Copes-Vulcan Variable-Orifice desuperheater that so effectively controls steam temperature.

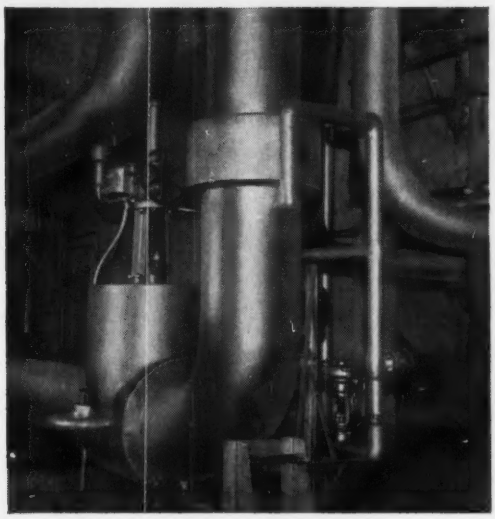
Cooling water enters through an annular orifice surrounding the ring seat at the point of maximum steam velocity. The passage of steam through the annular restriction between ball and seat produces an aspirating effect on the cooling water and entrains it in an area of high turbulence over the full range of flow.

No long run of piping is needed to mix the two fluids. There is no excess water to remove. No atomizing steam is used. There are no glands, stuffing boxes or spray nozzles. Pressure drop remains constant for all flows, and is normally 3 to 4 psig. Write for Bulletin 1037.



The problem: to maintain the temperature of residual fuel oil at 335°-380°F using station steam at 1250 psig and 950°F. Because of the high temperature heating requirements of the fuel, it was necessary to use the station steam supply. To handle this tough assignment a single, combination pressure-reducing and regulating valve, Copes-Vulcan Type CV-D, followed by the Copes-Vulcan Variable-Orifice desuperheater was used. The cooling-water valve is also a Type CV-D. The desuperheater provides steam at the right temperature to control the fuel oil temperature and viscosity exactly. It has been in service over two years with no downtime and no operating problems.

solves knotty problems at two generating plants



The problem: to deliver 420°F steam at from 20,000 to 300,000 pounds per hour and within ± 5°F of the set point. Conventional desuperheating equipment could not be used because of the low superheat (30°F) and low flow conditions. A 12-inch, 300-psig standard Copes-Vulcan Variable-Orifice desuperheater, with outlet expanded to 20-inch pipe size, was the answer. The inlet is connected with the main steam-distribution header carrying steam at 220 psig and 500°F. The cooling-water supply is at 450 psig and 200°F. The specified pressure range is 425 to 475 psig. Cooling-water flow is automatically regulated by a Copes-Vulcan Type CV-D valve operated by a temperature controller in the steam heating supply line. Flow requirements at discharge temperature within ± 5°F have been met consistently though inlet temperatures vary from 520°F to 550°F.

Copes-Vulcan desuperheaters are designed for precise control of reduced steam temperatures under the most difficult operating conditions.

In addition to the Variable-Orifice, two other types are available. *The Carburetor-Type desuperheater* injects cooling water into the system with a spray nozzle. Available in standard 2-inch through 12-inch sizes in 150- through 600-pound pressure standard for cast steel. Larger sizes and higher pressure standards are available on special application. Write for Bulletin 1056.

Steam-Assist desuperheater has negligible permanent pressure loss on loads of 15% to 100% of maximum. This in-line desuperheater normally uses assisting steam only on light loads where control is most difficult. Write for Bulletin 1024-A. Copes-Vulcan Division, Erie 4, Pennsylvania.

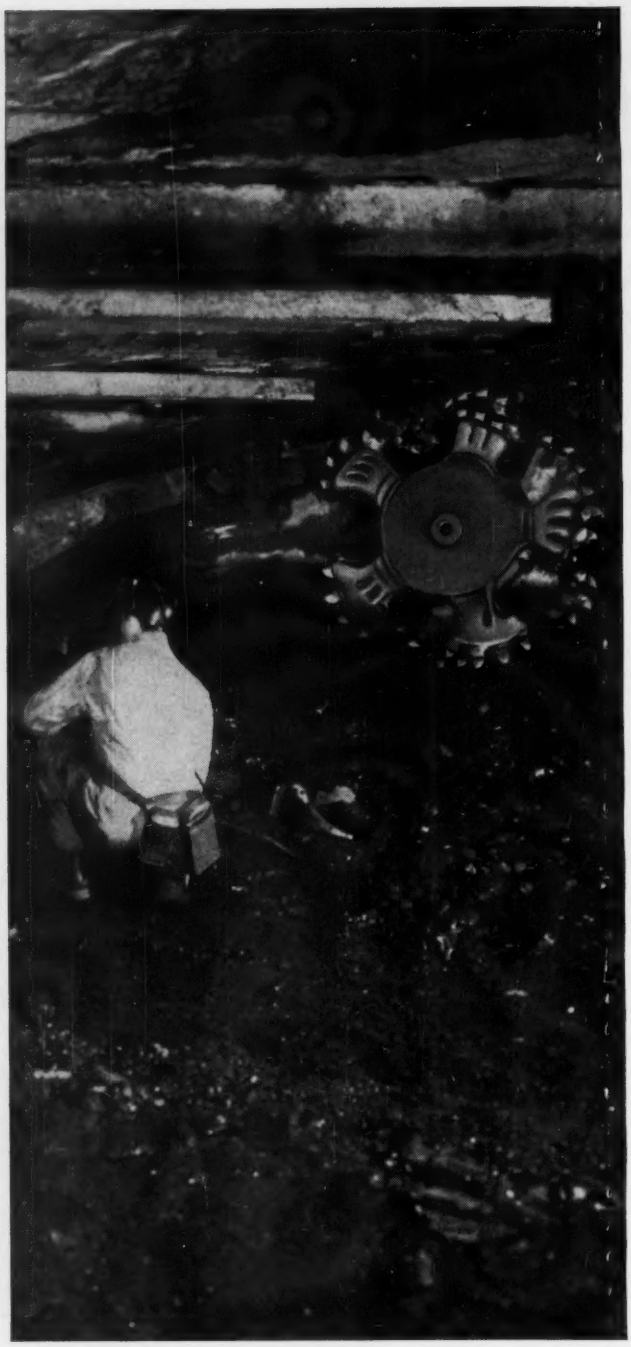
Copes-Vulcan Division

BLAW-KNOX

BLAW-KNOX

Blaw-Knox designs and manufactures for America's growth industries: METALS: Rolling Mills • Steel Processing Lines • Rolls • Castings • Open Hearth Specialties • PROCESSING: Process Design, Engineering and Plant Construction Services • Process Equipment and Pressure Piping • CONSTRUCTION: Concrete and Bituminous Paving Machines • Concrete Batching Plants and Forms • Gratings • AEROSPACE: Fixed and Steerable Antennas • Radio Telescopes • Towers and Special Structures • POWER: Power Plant Specialties and Valves

EASTERN OFFERS MORE THAN COAL



Coal buyers who look for the most for their fuel dollar know that a given coal has certain specific characteristics. They also know that the full value of the coal depends on the organization that produces it. Such extras as on-time delivery, consistent adherence to contract specifications, ready assistance in solving a complex fuel problem . . . all these and many others are of even more importance. That's why Eastern Gas and Fuel Associates stress the "extras" that are a part of every ton of coal they sell.

Call your Eastern representative for full information on how Eastern Gas and Fuel Associates can help you to make your fuel program more efficient, effective and economical.

RESERVES—Eastern Gas and Fuel Associates' properties include coals from the Pocahontas, Pittsburgh, Eagle, Hernshaw and many other well-known and desirable seams. Their total reserves will satisfy present production rates for more than one hundred years, and Eastern is constantly on the alert to acquire additional desirable acreage.

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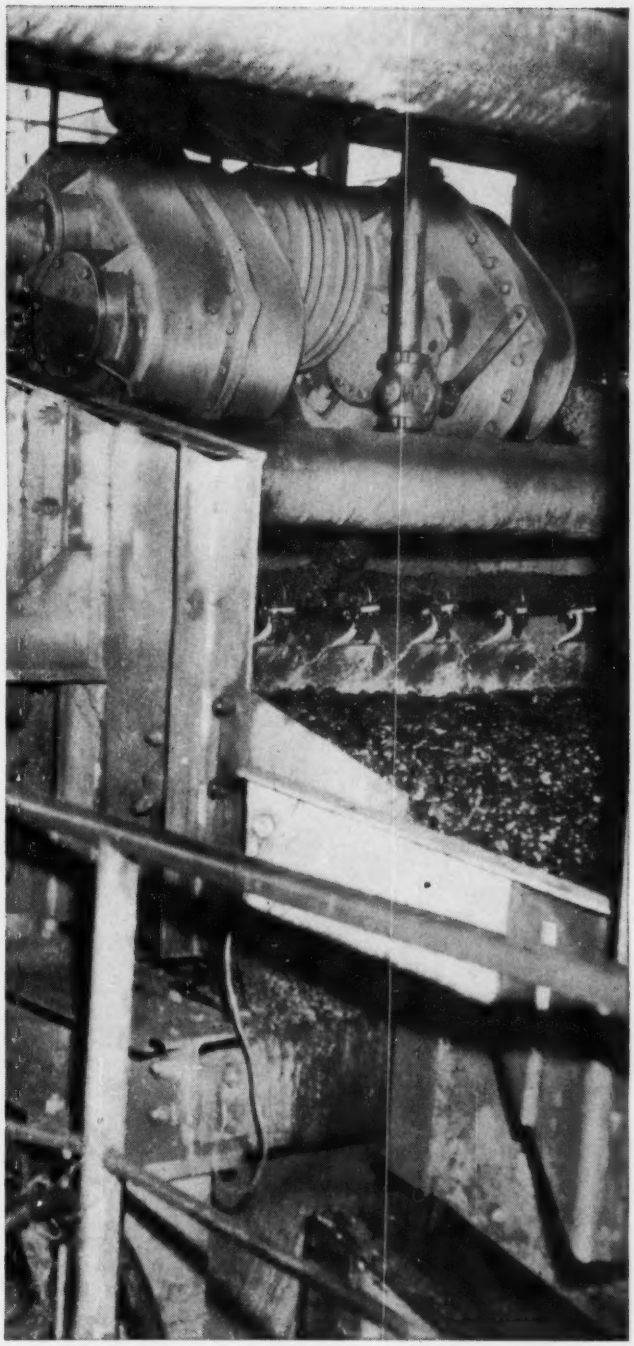
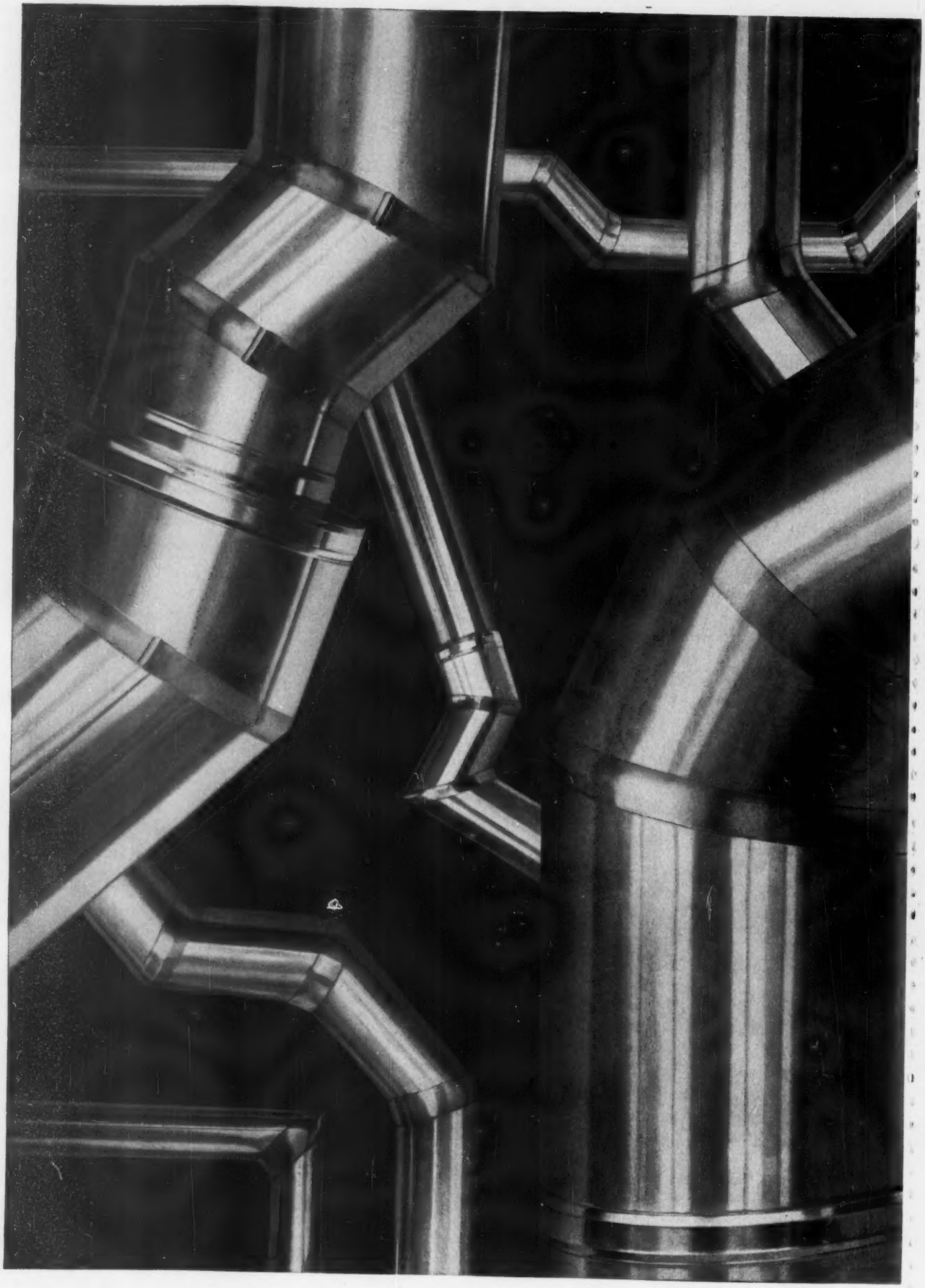


QUALITY—By the application of the most modern mining and coal preparation techniques, Eastern is in a position to meet requirements for specific types, sizes and grades of coal for both steam and metallurgical use. Eastern's modern preparation plants produce coals that are cleaned, sized and graded—coals *engineered* to suit your specific needs.

SERVICE/RESEARCH—Eastern's service is backed by a customer-oriented research program. While Eastern did not invent coal research, they established the *first* coal company research laboratory, and have made research an integral part of all their operations. Eastern's service includes basic research, close cooperation with customer engineering staffs, an integrated program of information exchange with equipment manufacturers and a tremendous backlog of technical information on present and potential uses of coal.

EASTERN GAS AND FUEL ASSOCIATES

For more facts circle 208 on Reader Service card, p 117



Now! J-M Metal-On covers all the angles

WITH NEW J-M MITER-SEALS, YOU CAN USE METAL-ON TO INSULATE ELBOWS, BENDS, SWEEPS AND TURNS

Now you can protect your *entire* pipe-line system with Johns-Manville Metal-On®...the Thermobestos®, calcium silicate insulation prejacketed with weather-proof aluminum. Yes, even the most complex elbows, bends, sweeps and turns can benefit from the superior insulation of Metal-On.

J-M research has developed Miter-Seal®, a factory-made, preformed aluminum band. It has a clip at one end that can be tightened in a flash with a J-M Banding Wrench. *One* measurement, *one* cut, *one* application, and both insulation and jacket are applied. A quick turn of the Banding Wrench on the Miter-Seal completes the job! (See below.)

For full details, write to J. B. Jobe, Vice President, Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada: Port Credit, Ont. Cable: Johnmanvil.

THE MATERIALS

Miter-Seal

J-M Banding Wrench

THE METHOD

Mitering section of Metal-On. Both jacket and Thermobestos are cut in one step with ordinary carpenter's saw.

Mitered section of Metal-On is placed on 90° fitting.

Miter-Seal sealing compound is placed in mitered joint.

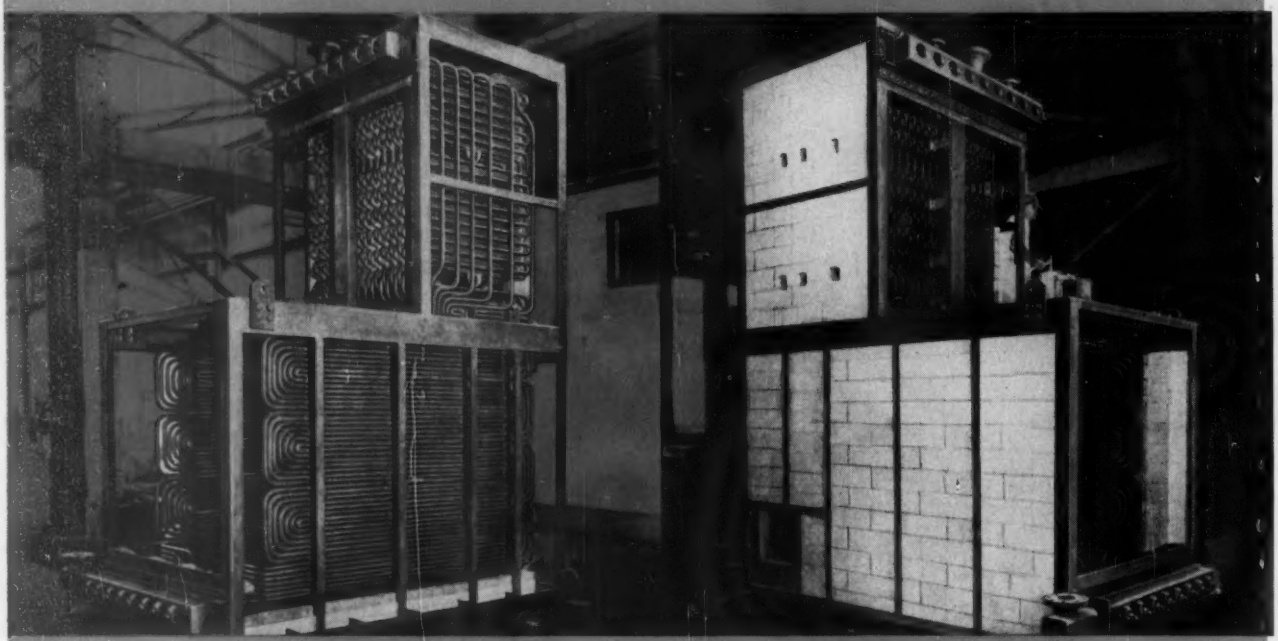
Miter-Seal bands are applied and tightened to finish fitting.

JOHNS-MANVILLE

AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

For more facts circle 209 on Reader Service card, p 117

for space heating... or process heat... investigate the ECONOMY and EFFICIENCY of C-E HIGH TEMPERATURE



1 Shop assembly of 12-million Btu C-E High Temperature Water Boiler. Shows steel frame and pressure parts.

2 Same unit with refractory insulation added.

Because the C-E High Temperature Water Boiler makes more heat available than does a steam boiler operating at the same pressure . . . because it allows closer temperature control . . . does not require steam traps or elaborate feedwater treatment . . . has no blow down or condensate losses . . . it is finding ever-wider use in large space heating and industrial processing operations.

Designed around the same controlled circulation principle used by C-E in many of the world's largest boilers, the C-E High Temperature Water Boiler (Type HCC) operates with low pressure loss. It offers complete control of system and boiler circulation and allows more efficient arrangement of heating surface. It is available for oil, gas, coal or combination firing.

Designed in a wide range of capacities – from 10 million to 300 million Btu's – these boilers operate at water pressures up to 500 psi and temperatures to 470F, or higher. Depending upon local conditions, a C-E Hot Water Boiler can save from 10 to 20 per cent in maintenance and operating costs.

The smaller capacity Hot Water Boilers are completely shop assembled, while the intermediate and large units are shipped in varying stages of assembly.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;

WATER BOILERS

3 A 25-million Btu unit completed with welded casing, ready for shipment. Cables are attached to lifting lugs.

4 Compact, completely shop-assembled units from 20 to 35-million Btu are shipped this way.

This C-E practice greatly reduces erection costs.

So, if you are in the market for boilers, either for space heating or process requirements, it may prove to your advantage to investigate the use of high temperature water as your heat source. Because individual needs vary, both steam and hot water have their place. Our engineers will be pleased to discuss either method with you or your consultants — impartially and with no obligation.

For further details on high temperature water boilers by C-E write for our catalog HCC-2.

COMBUSTION ENGINEERING

C-306

General Offices: Windsor, Conn.
New York Offices: 200 Madison Avenue, New York 16, N. Y.
Canada: Combustion Engineering-Superheater, Ltd.

PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

(Advertisement)

Rockwell-Edward Nuclear

Shippingport, Pennsylvania, 1961: After more than three years of operation, it is possible to report in depth on the manufacture and performance of Rockwell-Edward high-pressure steel valves built for Shippingport, pioneer nuclear power generating station. This report deals with two areas:

1. *How Rockwell-Edward quality control met rigid Shippingport requirements.*
2. *How relatively standard design Edward valves have performed in Shippingport nuclear service since startup in 1957.*

Quality Control

Quality control of the highest order in building steel nuclear valves for the Duquesne Light Company-operated Shippingport Station brought the valve maker's art to new heights. These valves, for the primary coolant system in the first full-scale nuclear power generating station, were furnished by Edward Valves in 1-inch to 18-inch sizes. Since no valves had ever been called upon to perform in such service before and since slightest valve failure could have consequences far more serious than any possible before, Edward was called upon to apply every conceivable technique of quality control known.

From the very beginning, physical and chemical analysis of all component materials was made on every lot and every heat. Statistical lot testing was not adequate.

Testing and Measurement

Normal valve making requires only that certain diameters and angles be watched to critical tolerances. But for the Shippingport valves, every dimension that could be measured was measured and checked to tolerances of thousandths of an inch. All forged steel valve bodies were ultrasonically tested to pick out body flaws that could lead to leaks or stress concentrations. Ultrasonic testing is not ordinarily warranted for valves as small as 1-inch size. After Stellite inlays were laid and machined for seating surfaces, dye penetrants were used to detect porosity, surface flaws, holes and crevices.

All internal surfaces were inspected with a Boroscope. Roughness was held to 30 microinches.

Precision and Cleanliness

Though lapping is usually reserved for valves destined for gas service, the Shippingport valve seats were hand lapped to a maximum roughness of 16 to 30 microinches, rms. All internal surfaces exposed to fluid were polished to 125 microinches, rms. Such fine internal finishing is very difficult on small valves, but had to be done. All internal surfaces were inspected with Boroscopes.

All cleaning and degreasing as well as final assembly were done in the "clean room". All personnel wore lint-free coveralls. No smoking was permitted.

Final Tests

Two-hour hydrostatic tests, back seat tests, and packing tests were done in the "clean room," also. After tests, the completed valves were again oven dried in nitrogen and inspected with a Boroscope for cleanliness, porosity and surface finish. These inspections were made by Edward and representatives of Westinghouse Electric Corp. and the United States Navy. Valves were sealed in polyethylene bags and then removed from the "clean room" for packing according to military standards.

Experience with rigid quality control conditions such as these is hardly routine. But it illustrates what a valve maker can do with his standard line.

Performance Record

Not a single complaint has been received on any of the more than 100 Edward one-inch and two-inch forged steel globe stop valves used in the high-pressure primary reactor system, or on the four 18-inch tilting disk check valves used in the primary coolant pump discharge lines.

A few of the globe stop valves have required routine seat maintenance, but no more than would be expected. Leakage through the packing of the globe stop valves has been consistently within expected limits . . . that

(Advertisement)

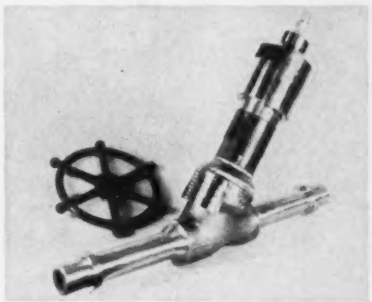
Valve Report:

is, so minute as to be of no consequence. In fact, although many of the Edward globe stop valves were furnished with weldable caps as a precaution against packing leakage, the caps have been welded into place only on those valves in relatively inaccessible areas near the reactor.

Forged steel valves for Shippingport—and for the Westinghouse Belgian reactor and other nuclear projects—were individually sealed in plastic bags.

In furnishing high-pressure steel valves for virtually every U.S. nuclear power plant built to date, Edward has demonstrated that excellence of design and manufacture is *the* important ingredient in nuclear power valving, just as it has been in conventional power valving for more than fifty years. They have proved that there *are* important differences in various steel valve lines . . . and that Edward customers get the benefit of these differences.

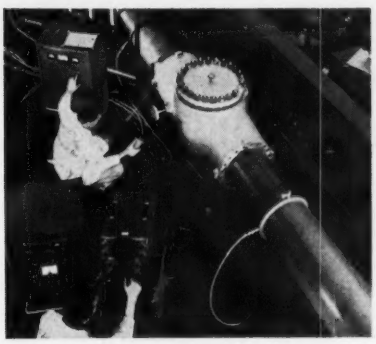
Edward builds a complete line of forged and cast steel valves from ¼″ to 24″ for power, industrial, marine, and petroleum services. For more information, contact your Edward Representative, or write Edward Valves, Inc., 1230 West 145th Street, East Chicago, Indiana. Subsidiary of Rockwell Manufacturing Company. Represented in Canada by Lytle Engineering Specialties, Ltd., 438 St. Peter Street, Montreal.

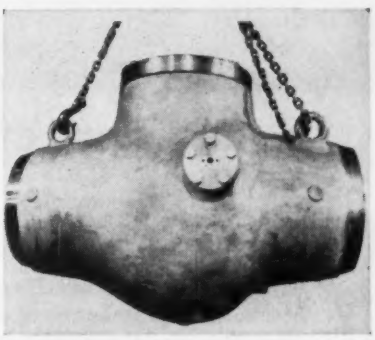


This valve is typical of smaller capped forged steel stop valves furnished for Shippingport. Cap has been screwed into position on bonnet but has not been seal-welded.

Big Cast Steel Valves, Too

The development of suitable check valves for pump discharge service in primary coolant loops of large pressurized water reactors has been substantially advanced by exhaustive flow testing begun in the Edward research laboratories in the 1940's. Equipped with a flow test loop circulating up to 2,000,000 lb/hr of water and capable of flow reversal in a fraction of a second, Edward research engineers have been able to simulate actual service conditions and develop check valve designs with superior opening and flowing characteristics together with the best possible non-slam features upon flow reversal. Full size prototypes of Shippingport, N. S. Savannah, Enrico Fermi, and Indian Point primary loop check valves were tested with this equipment.



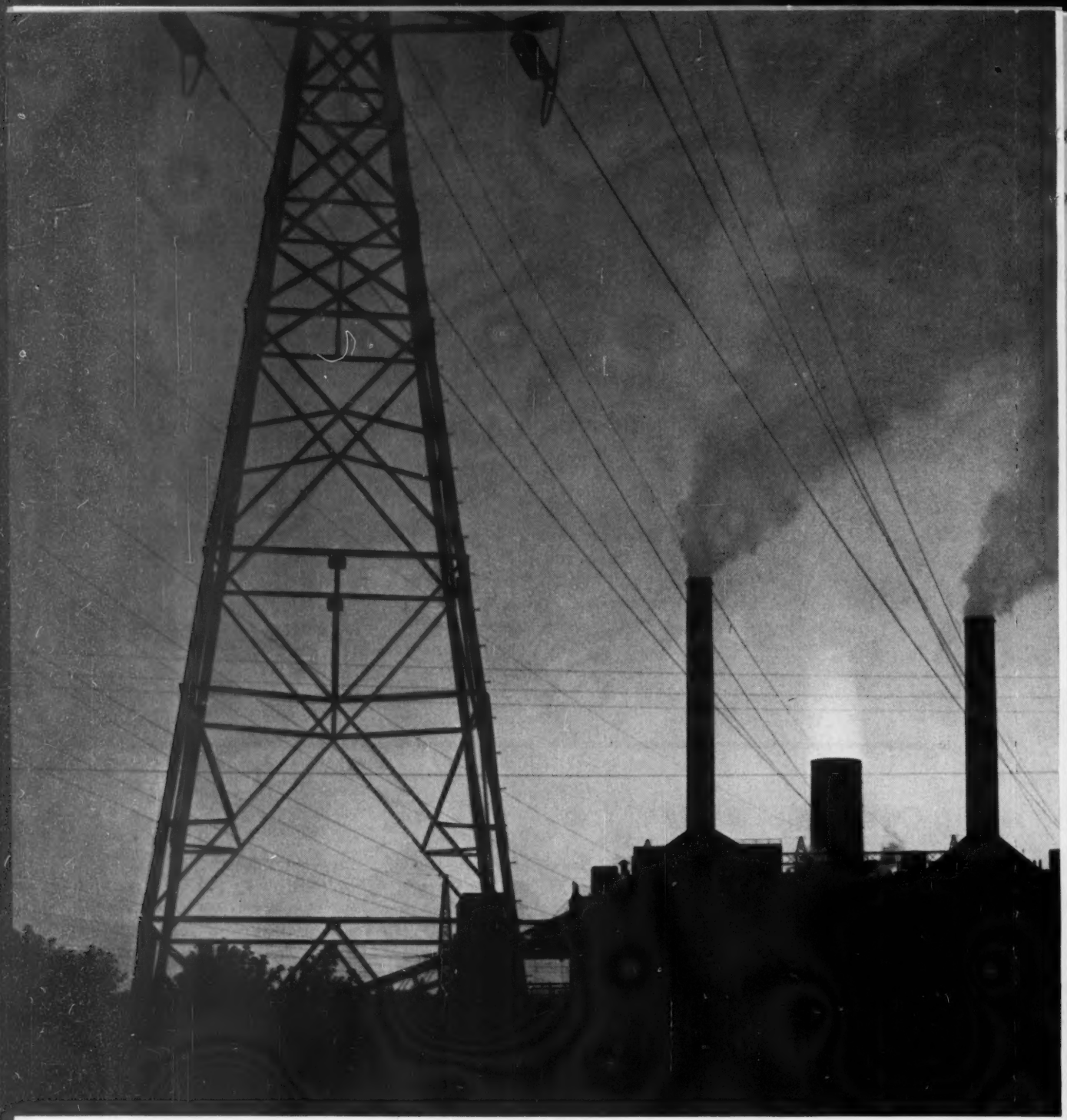


6104

Large 18-inch cast steel stainless steel check valves for Shippingport (left) received same meticulous attention as small forged valves . . . and have functioned with equal dependability since going into service in late 1957.

Other large Rockwell-Edward stainless steel valves were built for primary coolant systems of Babcock & Wilcox N.S. Savannah (center) and Indian Point (right) reactors.

EDWARD STEEL VALVES
another fine product by
ROCKWELL



A statement of importance to the electric utility industry

Four years ago the first Universal Pressure boiler system went on the line. This was the pioneer installation at the Philo Plant of Ohio Power Co. (AEP System).

Today, 16 Universal Pressure boiler systems—totalling 6,450,000 kw—are installed or on order from Babcock & Wilcox.

During this time, the Universal Pressure boiler has become a major tool to help the industry reduce the cost of power generation. It has thoroughly demonstrated four important advantages: reduced overall plant capital costs, increased availability, increased economy, and lower maintenance costs.

1. Reduced overall plant capital costs. A Universal Pressure boiler weighs 20% less than a drum unit. This means smaller foundations, less building steel, faster erection.

2. Increased availability. A true once-through unit, the boiler's inherent simplicity is resulting in 95% boiler availabilities.

about the B&W Universal Pressure boiler.

3. Increased economy. Ability to maintain steam temperatures over the entire operating range improves the plant's overall efficiency.

4. Lower maintenance costs. After trip-out, the boiler can be entered in 2½ to 3 hours. Fast cold starts and hot restarts can be made without thermal shock.

After careful evaluation of operating results of Universal Pressure boiler sytems, we strongly recommend its use for all electric utility applications involving turbine throttle pressures 2000 psi and up. We firmly believe that a review of the UP boiler system for your specific conditions will show it as the boiler to specify for high-temperature, high-pressure service.

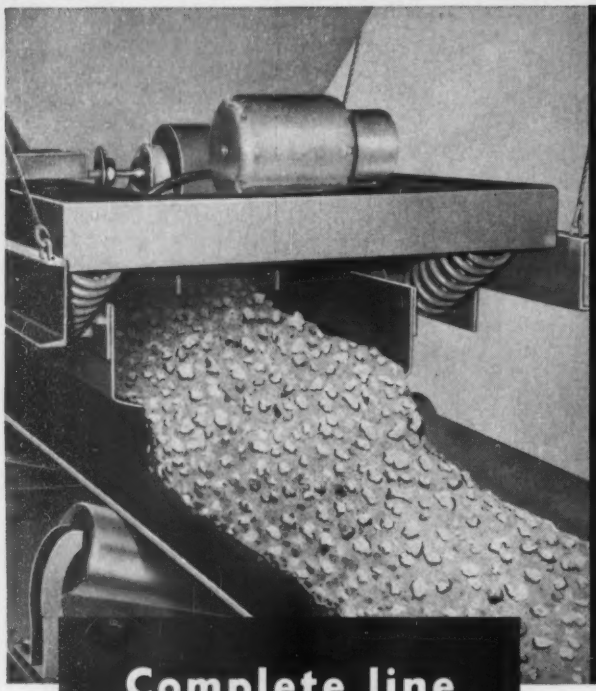
Your B&W representative would be glad to review the benefits of UP boilers with you on request.

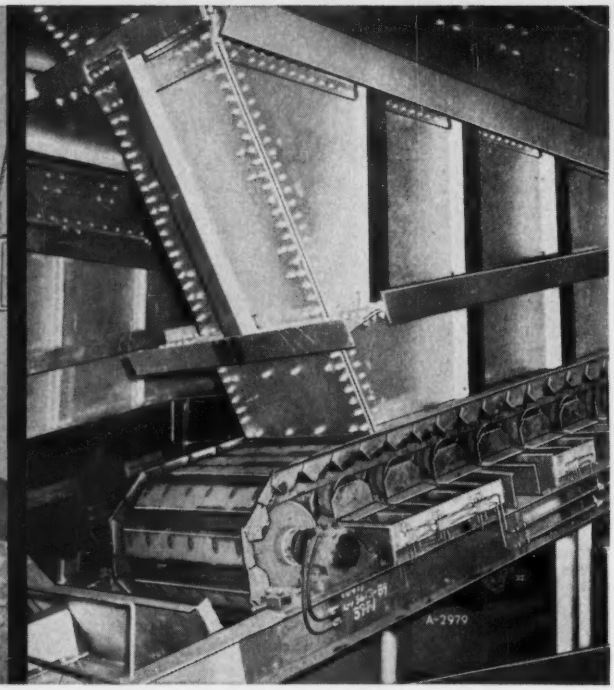
The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

Babcock & Wilcox

For more facts circle 212 on Reader Service card, p 117

STEPHENS-ADAMSON

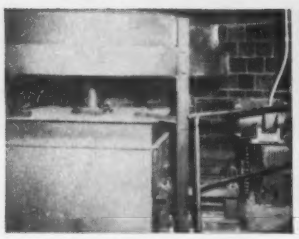




Complete line of FEEDERS for every bulk material handling requirements

STEPHENS-ADAMSON builds a complete line of Feeders to meet every need. From light duty apron units handling small tonnages per hour to giant AMSCO* Feeders built to take the impact delivered by thousands of tons of run of mine ore and stone. The introduction of the revolutionary all new S-A "Solid Stroke" Variable Rate Vibrating Feeder opens a broad horizon of feeder applications across a wide range of industries. The new unit utilizes the well known principle of natural frequency over its full operating range. Its exclusive solid drive principle provides 50 to 100% greater capacities per given size feeder than has heretofore been attained. In addition, S-A has a complete line of apron, pan, reciprocating and rotary plate feeders. Provide the problem and S-A will furnish the required feeder to meet your bulk materials handling needs. Move materials fast, efficiently and at the lowest cost per ton via S-A Feeders. Write for full details.

*Registered Trademark American Manganese Steel Co.



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S-A AC and AD FEEDERS
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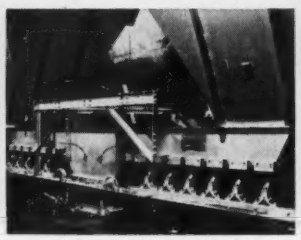

S-A APRON FEEDERS
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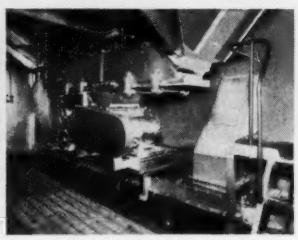

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SPHERCO® BEARINGS & ROD ENDS

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ENGINEERED APPLICATION of pumping systems means getting the right pump to do your liquid-handling job most efficiently.

Meaning? You must choose from a wide variety of pump designs, sizes, materials, performance characteristics. You need to know what special pumps handle acids, paper stocks, corrosive alkalies, salt water, slurries.

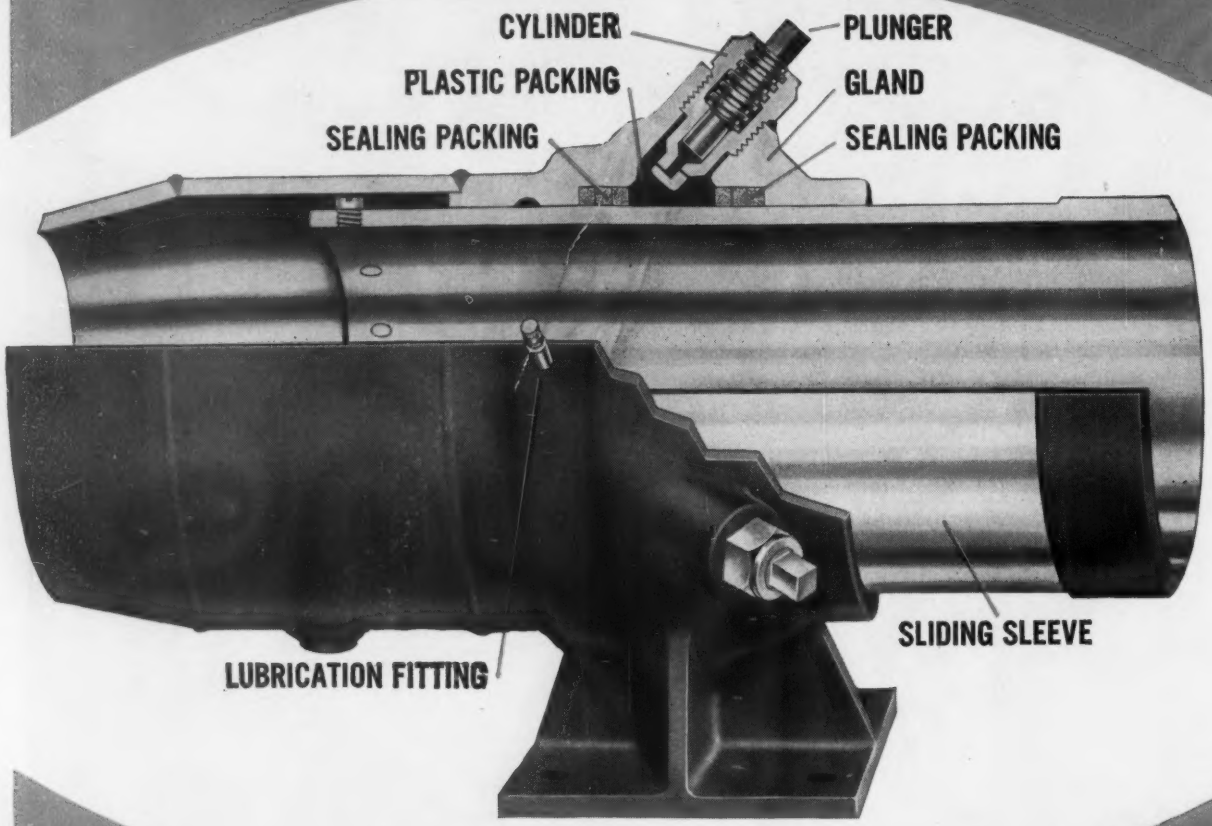
Impossible? Not for an expert. And Goulds provides the expert every time you need a pump. Goulds' application engineers specialize in every pump field to help you select *just* the pumping system you need.

The next time you're faced with a decision on what pump to buy, call in a Goulds man to look the problem over. He'll cut corners where he can, but make no sacrifices of quality or safety. And when he says, "This is it!" you can *depend* on it.

For help in solving *your* pumping problem, write to: Goulds Pumps Inc., Dept. PO121, Seneca Falls, N. Y.

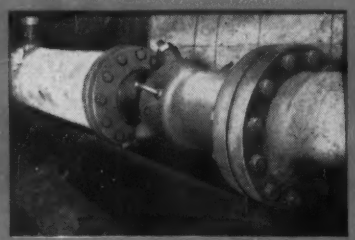
GOULDS GP PUMPS

GIVE STEAM and HIGH TEMPERATURE

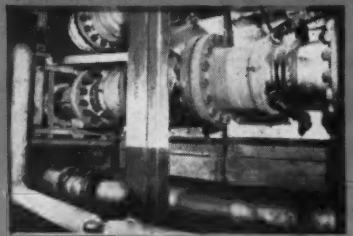


Only Yarway GUN-PAKT combines these outstanding features with design simplicity. GUN-PAKT Joints are available in single or double ends, welding or flanged, and in standard pipe sizes up to 30".

• 5 of 36 Yarway Gun-Pakt Joints, 2½" to 16" sizes, welding ends on steam lines at mid-west state institution.



• 6" Yarway Gun-Pakt Joint, flanged ends, on steam line at eastern industrial plant.



• Two 10" Yarway Gun-Pakt Joints, flanged ends, on return line of high temperature water system at New Jersey industrial plant.

• Group of 8" Yarway Gun-Pakt Joints, with automatic lubrication, on high temperature water lines at large international airport.

WATER LINES THESE BENEFITS...

✓ *TROUBLE-FREE SERVICE*
✓ *LOW MAINTENANCE*
✓ *SIMPLIFIED DESIGN*

WITH YARWAY GUN-PAKT EXPANSION JOINTS

Only Yarway GUN-PAKT Expansion Joints offer *simplicity*, *efficiency*, and *freedom from the "headaches"* that plague many plant engineers. That's why more engineers are specifying Yarway for efficient operation of steam and high temperature water piping in industrial plants, institutions and universities.

Yarway GUN-PAKT Expansion Joints offer you these advantages:

CONTINUOUS SERVICE—Shutdowns are eliminated. Addition of packing is seldom necessary, but may be added *under full line pressure.* No vents. Never needs repacking. *One plant lost, through forced shutdowns, production valued at $25,000. a day—until joints were replaced with Yarway* GUN-PAKT.

RUGGED DEPENDABILITY — All-steel construction with durable, chromium-plated, seamless steel sleeves. No chance of *metal fatigue.* Wrought steel bases provide rugged, positive anchorage.

INTERNAL AND EXTERNAL GUIDES—Positive alignment of sleeve in stuffing box—*where it counts.*

LIGHT WEIGHT, STREAMLINED DESIGN—Requires less space to install, less space to maintain, smaller manholes, fewer joints needed per length of pipeline.

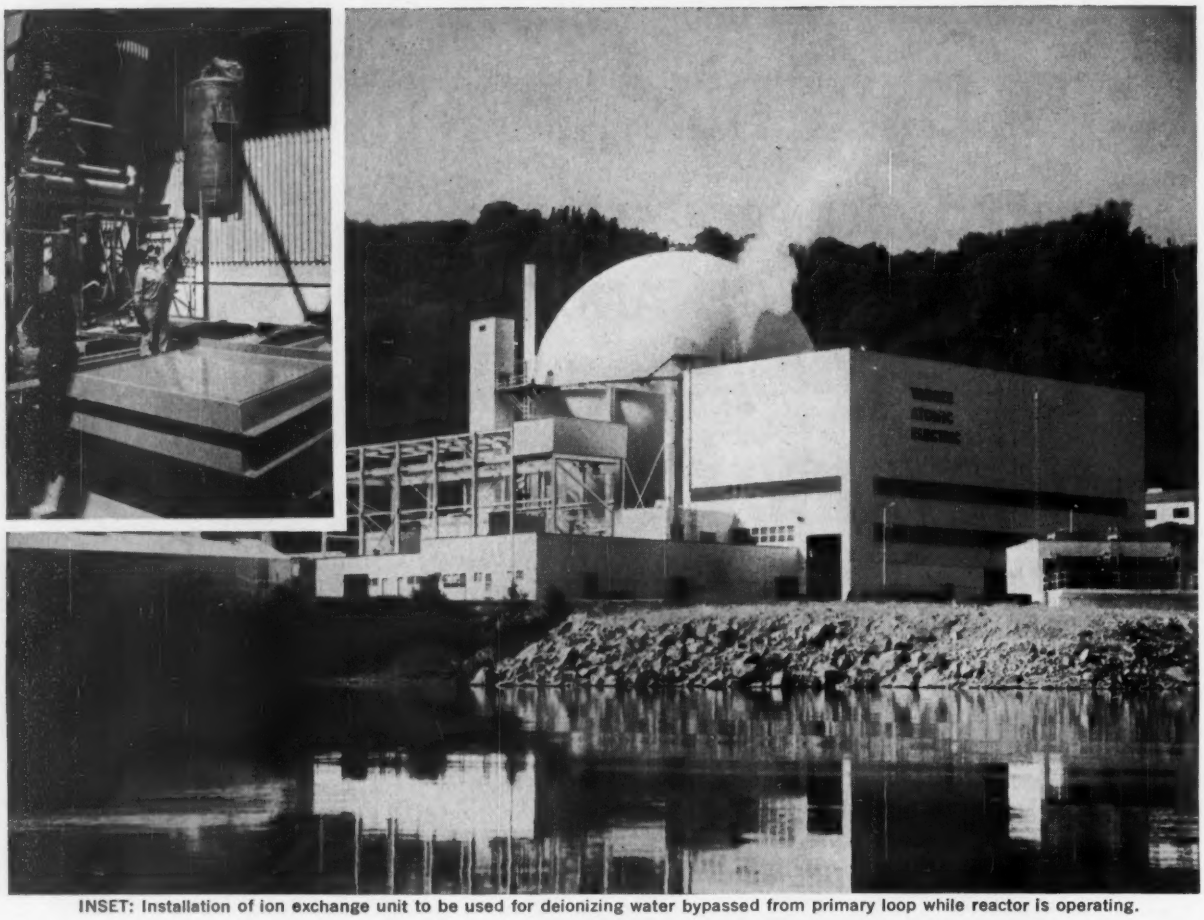
MINIMUM MAINTENANCE—Many GUN-PAKT Joints have been *in service over 25 years with only nominal maintenance*—no major repairs or periodic overhauls. NEVER A SHUTDOWN FOR REPACKING. Maintenance records show an average of one manhour and 65 cents worth of packing needed per joint per year.

Why don't *you* investigate the advantages of GUN-PAKT Joints now? A Yarway engineer will be glad to discuss the subject with you. Invite him to call. Ask for Yarway Bulletin EJ-1917, too.

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY

For more facts circle 215 on Reader Service card, p 117



INSET: Installation of ion exchange unit to be used for deionizing water bypassed from primary loop while reactor is operating.

How do your ion exchange requirements compare with those of Yankee Atomic Electric?

AMBERLITE® ion exchange resins do three critical jobs for Yankee Atomic Electric Company, at this new 136,000 kw. atom-powered station in Rowe, Mass.: (1) The most important is to provide reactor-grade makeup water for both primary and secondary loops of the pressurized water reactor. Raw water is taken from the Deerfield River, clarified and filtered, then passed over AMBERLITE IR-122 cation exchanger and AMBERLITE IRA-400 anion exchanger. (2) Water is continuously bypassed from primary loop and passed over AMBERLITE XE-150 to remove ionic impurities formed by corrosion reactions. (3) AMBERLITE XE-78 is used to remove borate ions from primary coolant water after cold shutdowns (boric acid solution is used to stop the nuclear reaction when the reactor is cooled below normal operating temperature).

Whether or not your water conditioning requirements are as stringent as these, Rohm & Haas can supply you with ion exchange resins that will serve you efficiently and economically. We will gladly furnish technical information on our complete line of AMBERLITE ion exchange resins.

Write for this free booklet of case-history information on the many ways industry is using AMBERLITE ion exchange resins.

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AMBERLITE

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B-E-H mono-block®

delivers higher insulating efficiency at lower installed cost

Any way you figure it, you'll get a better job at lower cost with Mono-Block. Thickness for thickness, Mono-Block delivers more margin of protection than most other block insulations. And because it's so much easier to handle, so much faster to apply, installation costs on Mono-Block go down by as much as 15% to 20%.

Higher Maintained Efficiency! The patented B-E-H manufacturing process assures greater integrity of binder and mineral fiber... provides longer periods of peak efficiency at high temperatures.

Lower Installed Cost! On any installation, large or small, Mono-Block delivers these outstanding engineering advantages: 1. Easy cutting for perfect fit . . . straight, odd-shaped, mitered, angled or curved. 2."Push-over" impaling on studs or pins... without drilling holes. 3. Two by three foot blocks mean faster coverage, easier handling... and Mono-Block's strength reduces possible damage when installing. 4. Mono-Block's built-in "give" allows it to fit snugly over projections, without cracking or breaking. The outer surface stays flat and smooth.

At Your Service! For technical data and service, call your local B-E-H contractor. For engineering assistance — from information to installation — write Baldwin-Ehret-Hill, Inc., Room 701 500 Breunig Ave., Trenton 2, N. J.

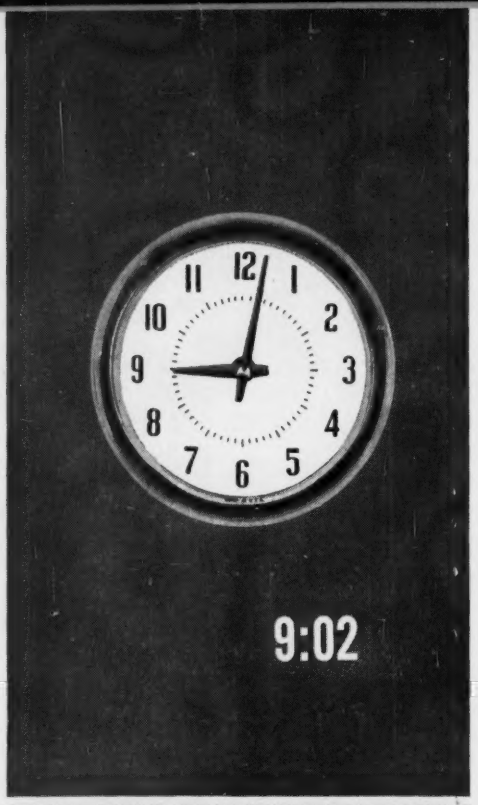
B E H
BALDWIN EHRET HILL

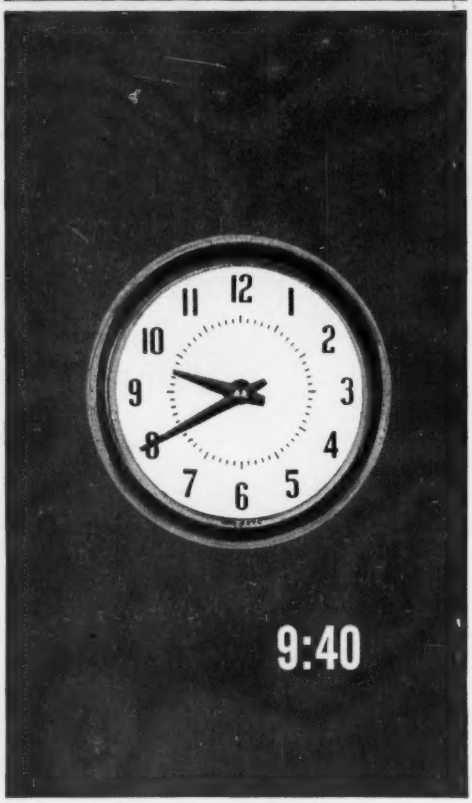
BALDWIN-EHRET-HILL, Inc.

Manufacturers of a complete line of pipe, block, felt and blanket insulation for temperatures from near absolute Zero to 2100 F.

For more facts circle 217 on Reader Service card, p 117

Westinghouse F/A motor completely disassembled in 90 minutes

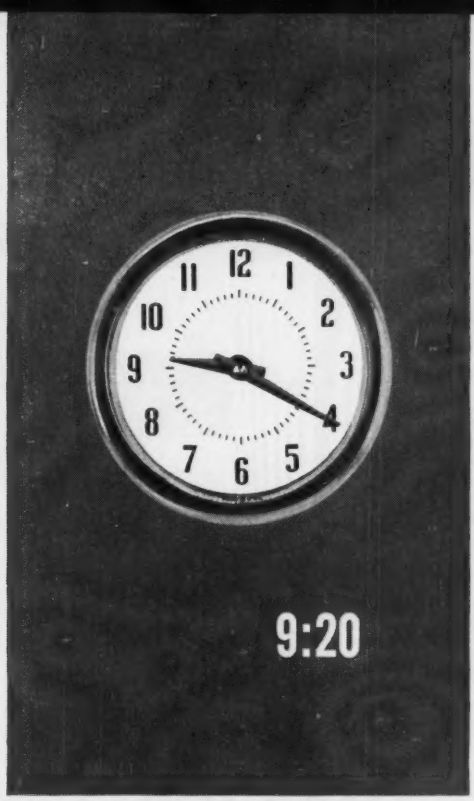




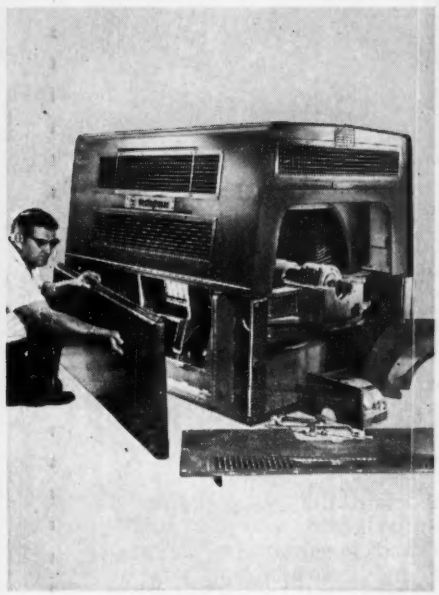
Only 90 minutes are required to completely disassemble the Westinghouse F/A (fully accessible) motor. After cleaning, inspecting and servicing, the F/A motor can be completely reassembled and returned to service in about two hours. One maintenance engineer reports that an F/A motor is serviced in his shop in about one-fourth the normal time for comparably rated motors. F/A motors are available in ratings from 250 hp/600 rpm to 7000 hp/3600 rpm. For more information, call your Westinghouse representative. Or, write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. *You can be sure . . . if it's Westinghouse.*

For more facts circle 218 on Reader Service card, p 117

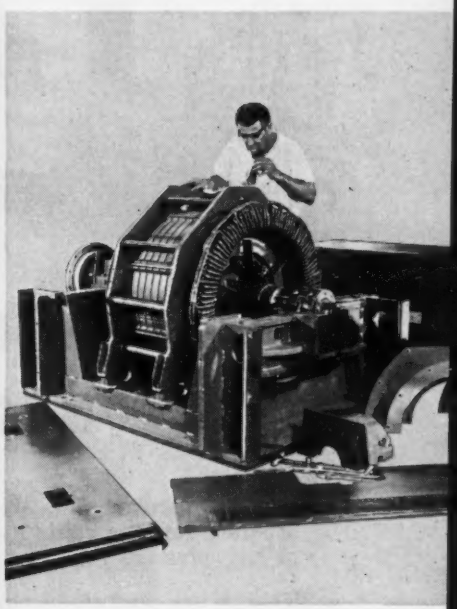
Motor stopped; disassembly begun.



Sufficiently disassembled to permit bearing inspection.



End covers, side panels, air shields removed. Winding inspection now possible.

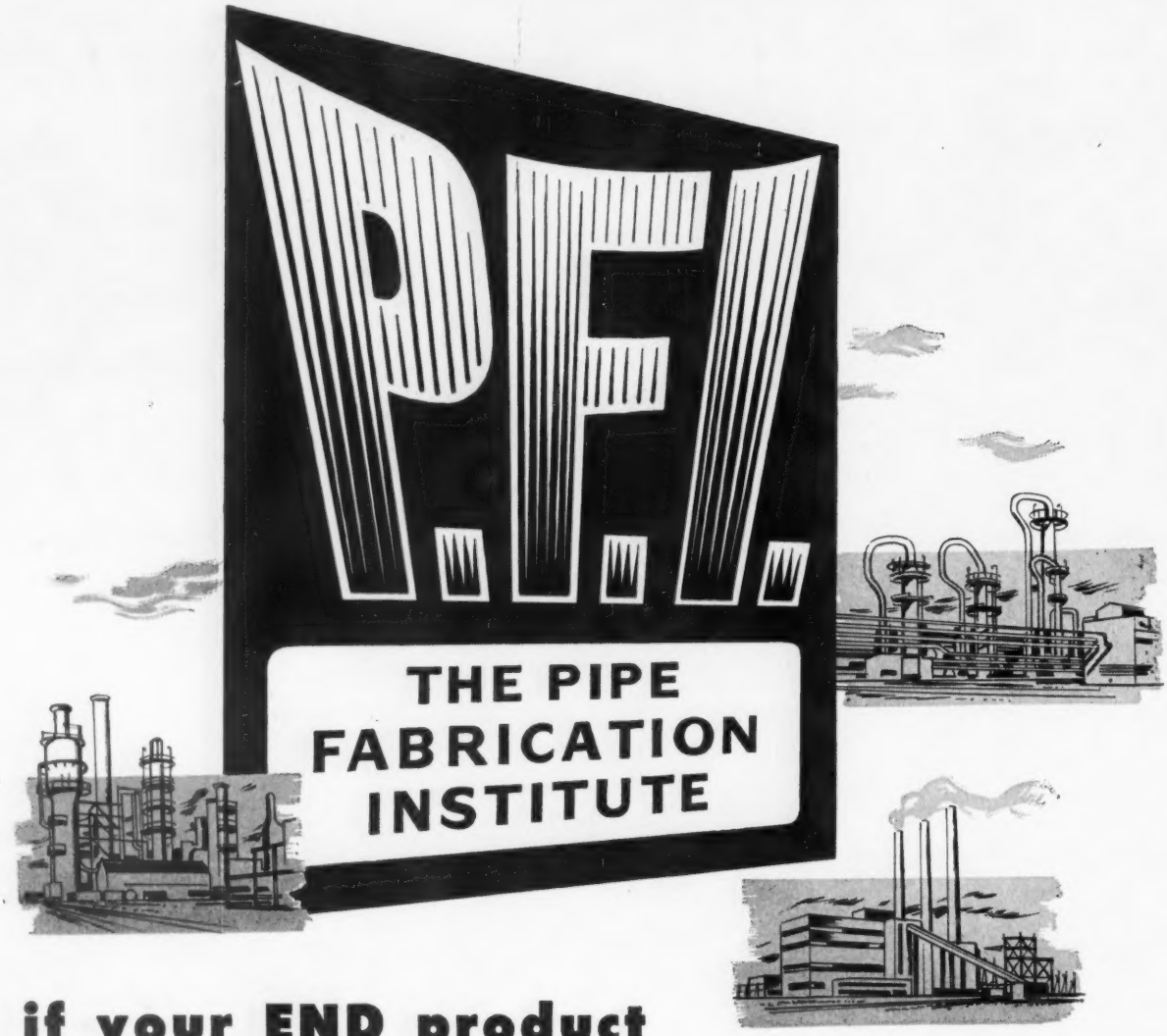


Complete disassembly possible for major cleaning, inspection and servicing.

d-15023

Westinghouse

...and reassembled in just two hours



if your END product BEGINS with piping...

Proper piping is always important for the accurate flow and control of high temperature or high pressure gases and liquids.

The selection of the piping material and its fabrication to specific forms can be costly for the original installation, but it can be even more expensive if it requires frequent maintenance, short-term replacement or if it fails to contribute to the economical production of your end product.

So, it is vitally important that your piping requirements be handled from blueprint to finished fabrication and assembly by thoroughly experienced and dependable piping specialists.

Members of P.F.I. are best qualified through coordinated research and advanced technology, and their individual fabrication facilities, to provide you with the most practical piping for long life and the economical production or handling of your products.

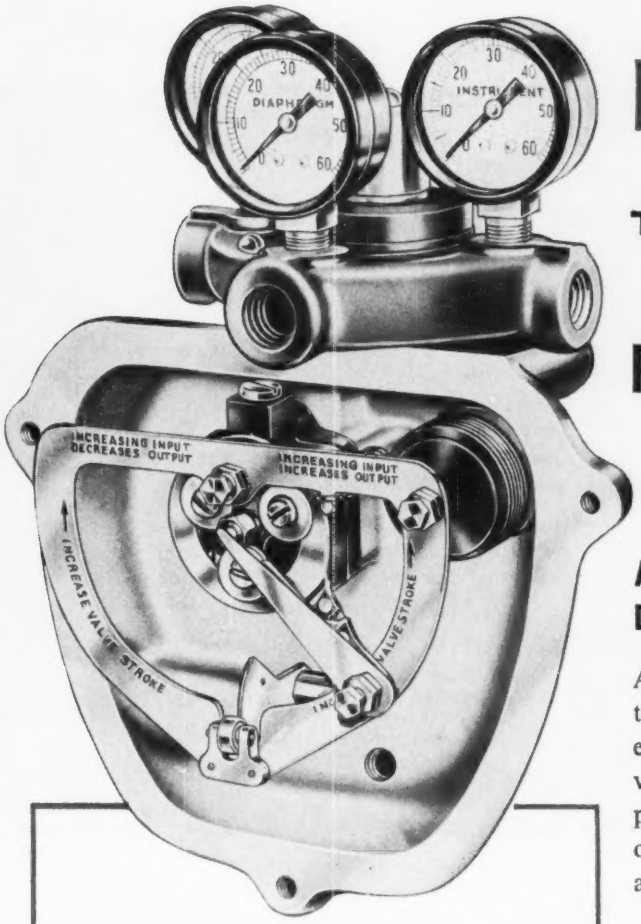
PIPE FABRICATION INSTITUTE • ONE GATEWAY CENTER • PITTSBURGH, PA.

Simply circle the Standards you can use and mail to PFI at the address above.

1 Machining Backing Rings for Butt Welds
2 Dimensioning Welded Assemblies
3 Linear Tolerances Bending Radii
4 Shop Hydrostatic Testing
5 Cleaning Fabricated Piping
6 Built-up Weld, Metal Bosses
7 Welded Nozzles — Spacing
8 Preheat - Postheat Welding, Low Chrome — Moly Pipe
9 Arc-Welding Dissimilar Ferritic Steels
10 Stress Relieving Practices
11 Affixing Permanent Symbols to Piping
12 Preheat - Postheat Welding, Medium Low Chrome — Moly Pipe
13 Classification, Shop Testing, Inspection, Cleaning

For more facts circle 219 on Reader Service card, p 117

A new concept in design makes possible the...



FISHER

TYPE 3560 VALVE POSITIONER

V/P

Assured product performance through DYNAMIC ANALYSIS engineering

Application of mathematical techniques of design to pressure control systems has enabled Fisher to eliminate the conventional approach in the development of the new V/P valve positioner. It has provided the V/P with the following combination of characteristics and performance . . . unobtainable in any other type of valve positioner.

SMALL AND COMPACT . . . only 6⅝" wide and 8¾" high (with gauges).

CONVENIENT ADJUSTMENT . . . valve stroke and zero adjustment readily accessible and easy to make.

SPLIT RANGE . . . no parts change whatsoever is required for split range operation.

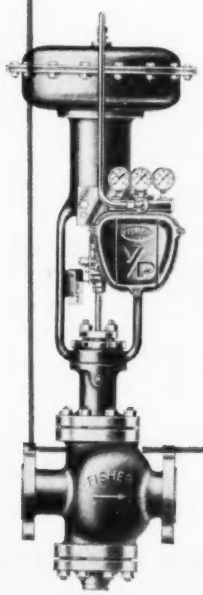
EASILY REVERSIBLE . . . reversed by simply moving flapper arm from one beam quadrant to the opposite quadrant.

CHARACTERIZED CAMS . . . offer wide flexibility in valve characteristics.

PERFORMANCE DATA

Hysteresis, (Average)	0.0012"
Linearity	as required. Change cams to obtain desired characteristics
Sensitivity	0.14 psi
Resolution Sensitivity	0.002 psi
Repeatability	±0.0003"
Stroking Speed	0.37 in/sec.
Air Consumption	10 scfh
Break Frequency (5% of instrument pressure range)	3.9 cps
Break Frequency (3% of instrument pressure range)	4.6 cps

The above performance data was taken from laboratory tests on a Type 657 diaphragm actuator, Size 40, with 1½" travel. Instrument range 3 to 15 psi.



Write today for Bulletin E-3560

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / Rochester, England

BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT COMPANY, CORAOPOLIS, PA.

FISHER® Controls

SINCE 1880

DE LAVAL

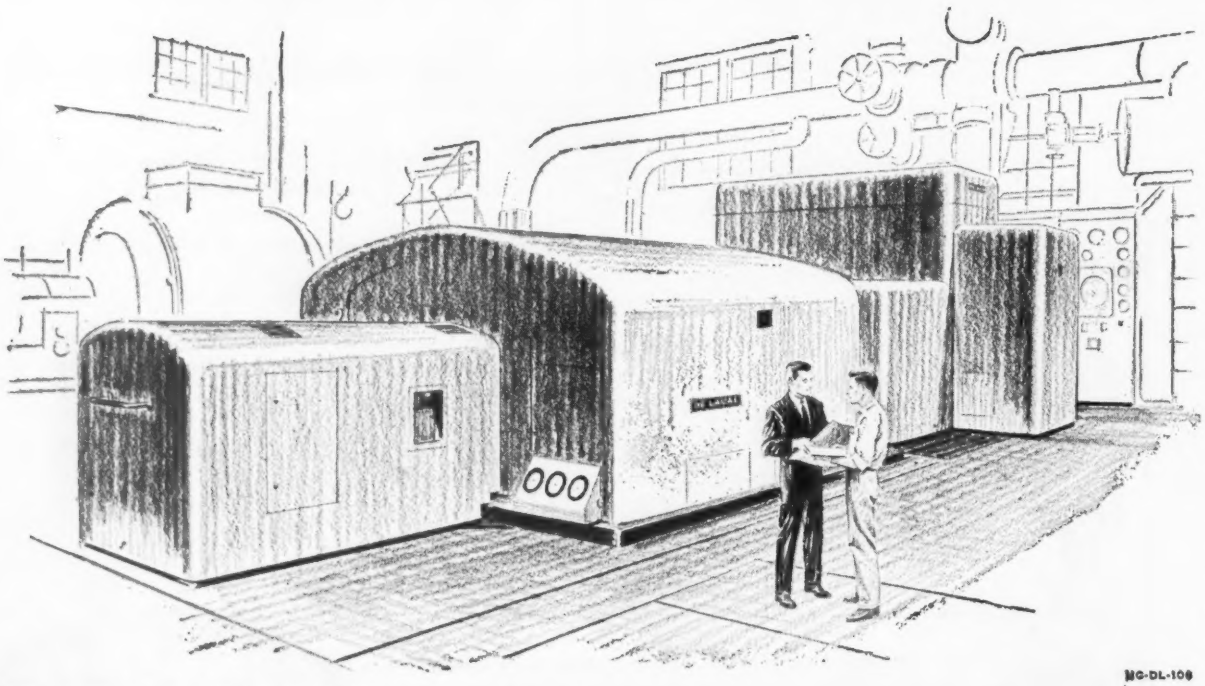
engineered flexibility lets a turbine "grow"

With his eye on tomorrow, a major food processor gave De Laval unusual requirements. He wanted a turbine that would meet today's power and process steam needs . . . and be capable of almost doubling its output in the future. The result: a De Laval turbine to which five additional stages can be added in the customer's plant.

Present capacity of this unit is 5,000 kilowatts which will be raised to 9,375. For future operations, steam pressure and temperature will also be sharply increased.

Whether you need a turbine that can "grow" or have other problems involving heavy rotating machinery, De Laval engineered flexibility can help.

De Laval Steam Turbine Company, Trenton 2, N. J.

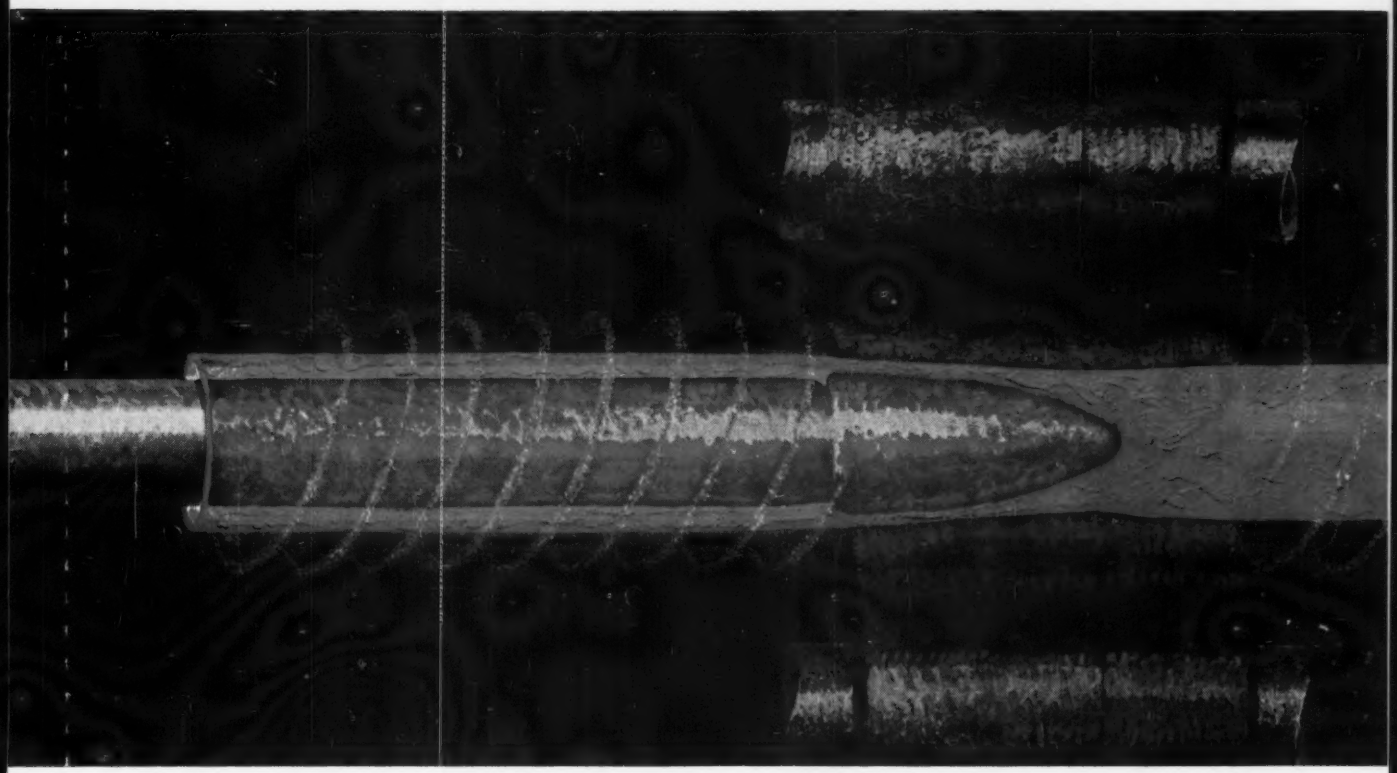


MC-DL-109

DE LAVAL · 60 YEARS OF CREATIVITY AND QUALITY

CENTRIFUGAL PUMPS AND COMPRESSORS • TURBINES • IMO® ROTARY PUMPS AND HYDRAULIC MOTORS
MARINE PROPULSION AND AUXILIARY EQUIPMENT • HELICAL AND EPICYCLIC GEARS • TURBOCHARGERS

What a tough way to come into the world!



The piercing operation is one of the first steps in creating seamless tubing from a solid section of steel. After we set the hot steel billet in place, we ram it. Spin it. Push its insides out. And stretch it into a tube many times longer than the original piece of steel.

Consider the grueling way USS National Seamless Pipe and Pressure Tubes are made and all the rigid tests they have to pass before we'll ship. You can see why seamless pipe or tubes are the strongest, safest tubular products you can buy. Contact your National Tube Distributor for USS National Seamless Pipe or Pressure Tubes.

USS and National are registered trademarks

Steel

This mark tells you a product is made of modern, dependable Steel.

USS

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco
Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York

For more facts circle 222 on Reader Service card, p 117

Water Hunting . . . With water all around us, in oceans, lakes and rivers, the hunt for suitable water still continues. Practically all water used in industry must be treated before use; and Cochrane, specialists in industrial water conditioning for almost a century, are constantly finding new and better methods of treating water. ● Cochrane has made many significant contributions to the art of water conditioning.They pioneered methods for removal of corrosive dissolved gases from water, developments which now form the basis of modern deaeration systems . . . Introduced advanced designs for silica reduction by demineralization . . . And in the softening of water, either by ion exchange or precipitation, many outstanding installations are meeting the stringent requirements of today's industry. ● Regardless of the raw water analysis, Cochrane's experience, covering every phase of water treatment, is your assurance of an unbiased recommendation and satisfactory performance. In water conditioning . . . the name is Cochrane. For complete equipment catalog, write on your company letterhead to Cochrane Division, Crane Co. 3106 N. 17th Street, Phila. 32, Pa.

at the heart of home and industry

COCHRANE DIVISION **CRANE** WATER CONDITIONING

plumbing
heating • air conditioning
valves and piping
electronic controls

For more facts circle 223 on Reader Service card, p 117

Here's maximum FLEXIBILITY of CONTROL

in a complete SUPERIOR package

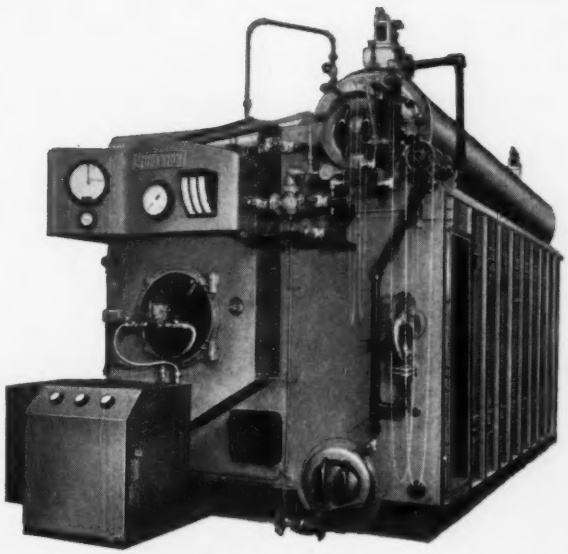
PNEUMATIC *or* ELECTRIC METERING *or* POSITIONING CONSOLE *or* PANEL

Combustion controls tailored to your operation and completely integrated in a Superior Packaged Boiler provide a combination that's hard to beat.

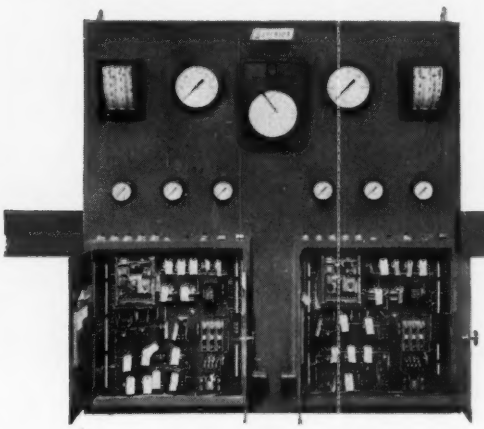
Electrically operated positioning controls for steam or rotary burners are supplied either in console arrangement or free standing panel. Metering controls, either electrically or pneumatically operated, are supplied with steam atomizing burners of all capacities in free standing panels which may be individual for each boiler or combined for two or more boilers.

Safety combustion controls are an integral part of every control panel. Complete factory wiring terminates in a boiler junction box with terminal strip matching identical strip in control panel.

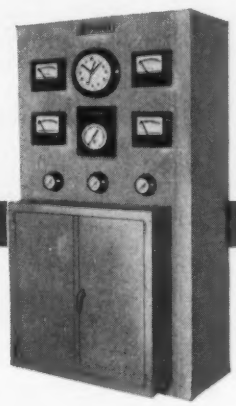
For complete data on Type D Boilers write for catalog D-11



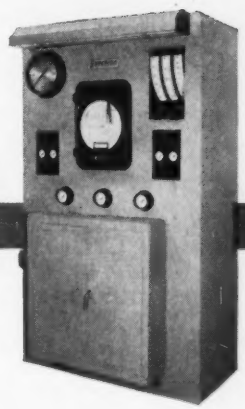
"Type D" Superior Packaged Boiler with integral console for single burners and electric positioning controls.



Duplex panel for two boilers with recording, indicating instruments and individually wired cabinets for combustion safeguard controls.



Control panel with indicating instruments for either rotary cup or steam atomizing burners with positioning controls.



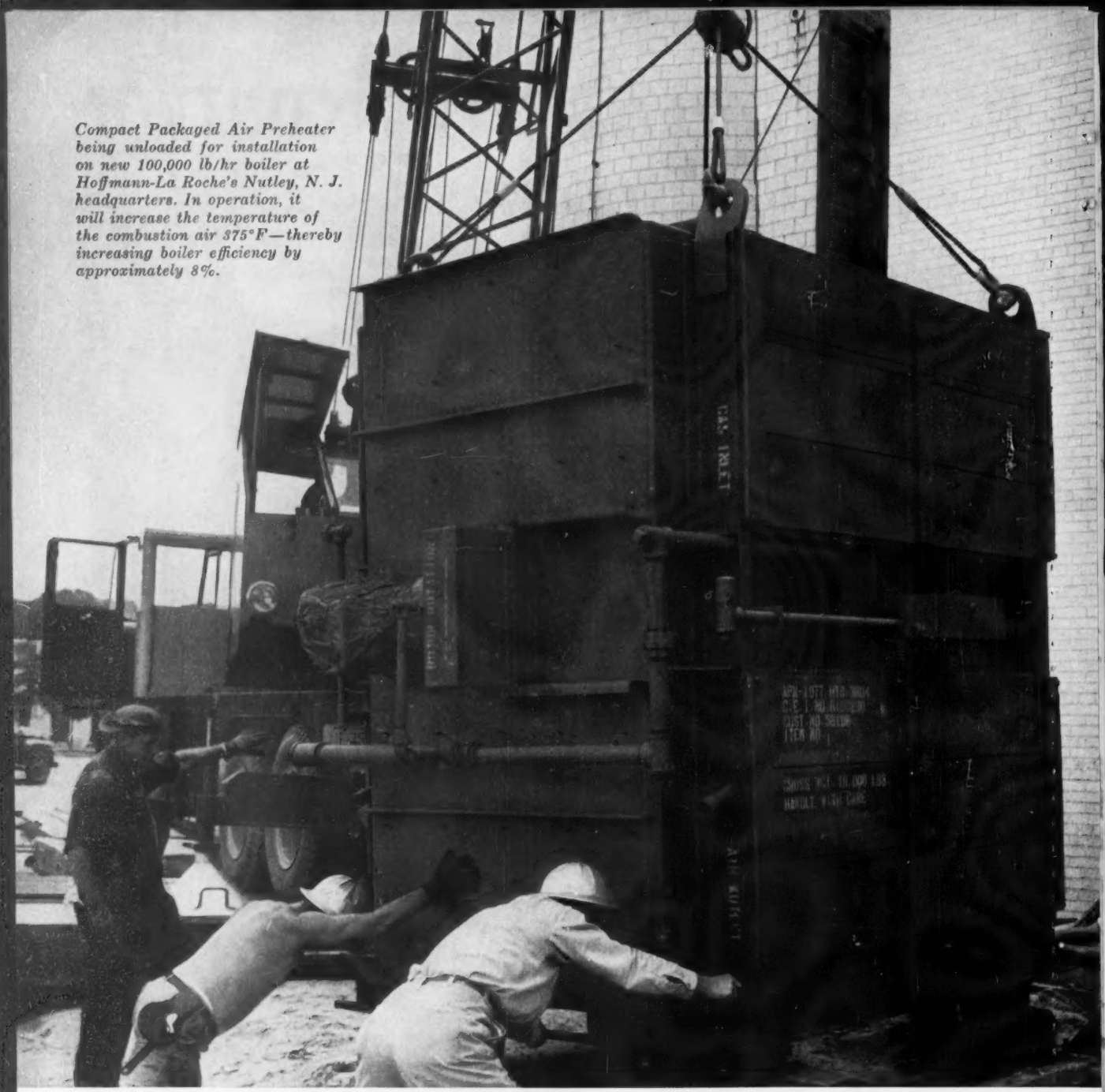
Control and instrument panel with pneumatically operated metering controls for steam atomizing burner installations of all capacities.

Specialists in PACKAGED BOILERS... exclusively

SUPERIOR COMBUSTION INDUSTRIES, INC.
TIMES TOWER, TIMES SQUARE, NEW YORK 36, N.Y.

SUPERIOR PACKAGED BOILERS

For more facts circle 224 on Reader Service card, p 117



Compact Packaged Air Preheater being unloaded for installation on new 100,000 lb/hr boiler at Hoffmann-La Roche's Nutley, N. J. headquarters. In operation, it will increase the temperature of the combustion air 375°F—thereby increasing boiler efficiency by approximately 8%.

PACKAGED AIR PREHEATER

WILL RECOVER 330°F FROM NEW BOILER FOR HOFFMANN-LA ROCHE INCORPORATED

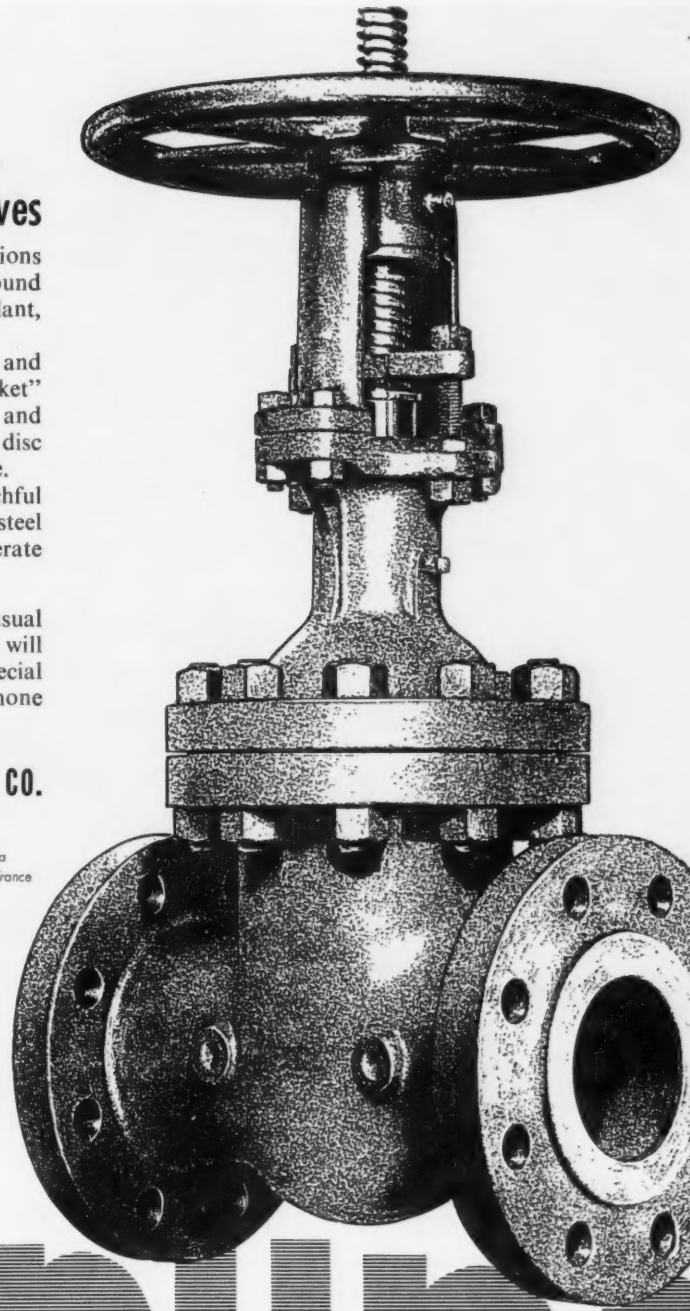
Hoffmann-La Roche, one of the leading producers of pharmaceuticals, vitamins and aromatic chemicals, specified a Ljungstrom Packaged Air Preheater for their new boiler for three reasons: 1) This compact, preassembled unit is ready to run as soon as it's connected to the power line and ducts—no extra installation or erection costs; 2) The unit occupies only about 450 cubic feet of space but will cut boiler exhaust temperatures from 680°F to 330°F—for about 8% saving in fuel; 3) Savings in fuel alone—roughly 1% for every 40°F drop in exit gas temperature—can pay for the unit in two short years!

Packaged Ljungstroms are available in sizes for use on boilers in the 25,000 to 250,000 lb/hr range—can give you these same fuel saving advantages. For full information, write today for our 14-page Packaged Air Preheater booklet.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

For more facts circle 225 on Reader Service card, p 117



Darling Cast Steel Gate Valves

are made in regular and special compositions to match the exact operating conditions found in high pressure refining, pipeline, power plant, and process industry services.

The revolving double disc parallel seat and wedge construction, with plain "no-pocket" discs, prevents accumulation of line scale and sludge. Discs are free to revolve and either disc will work equally well against the pressure.

Built by skilled specialists under the watchful eye of continuous inspection, these cast steel gates will seat perfectly, release easily, operate surely . . . *you can depend on Darling.*

ENGINEERING SERVICE. To meet unusual operating needs, Darling staff engineers will be glad to work with you in developing special valves for your services. Write, wire or phone for detailed information.

DARLING VALVE & MANUFACTURING CO.

Williamsport 8, Pa.

Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ontario, Canada
Vannes Darling-France, 23 rue du Commandant Mouchotte, St. Mandé, France

YOU CAN DEPEND ON

Darling

TRADE DARLING MARK

GATE • BUTTERFLY • CHECK • SPECIAL VALVES • FIRE HYDRANTS

For more facts circle 226 on Reader Service card, p 117

SARAN LINED PIPE—strong enough, inert enough for atomic power plant system

Almost 2,000 feet of Saran Lined Pipe, fittings and valves will carry non-radioactive acid solutions and sodium hypochlorite at Indian Point Station, N. Y., Consolidated Edison Company's atomic power plant.

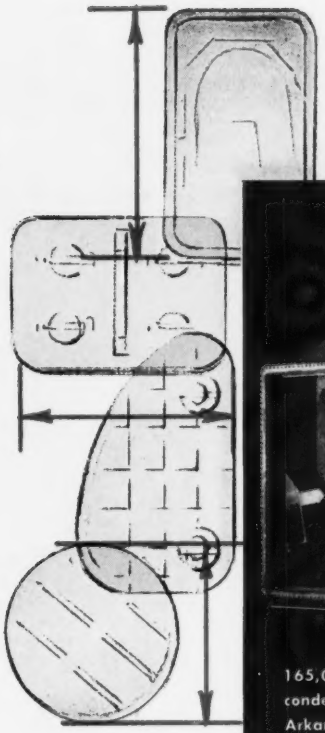
Saran Lined Pipe has the combination of chemical resistance and structural strength which severe service conditions of this type require, and it has been estimated that Saran Lined Pipe may give as long as 25 years of trouble-free service.

At Indian Point Station, Saran Lined Pipe was installed by an independent engineering firm. Project engineers point out that another advantage of this corrosion-resistant piping system is its ease and economy of installation. Crews easily cut and fit pipe without expensive prefabrication, without breakage, and using standard tools and equipment.

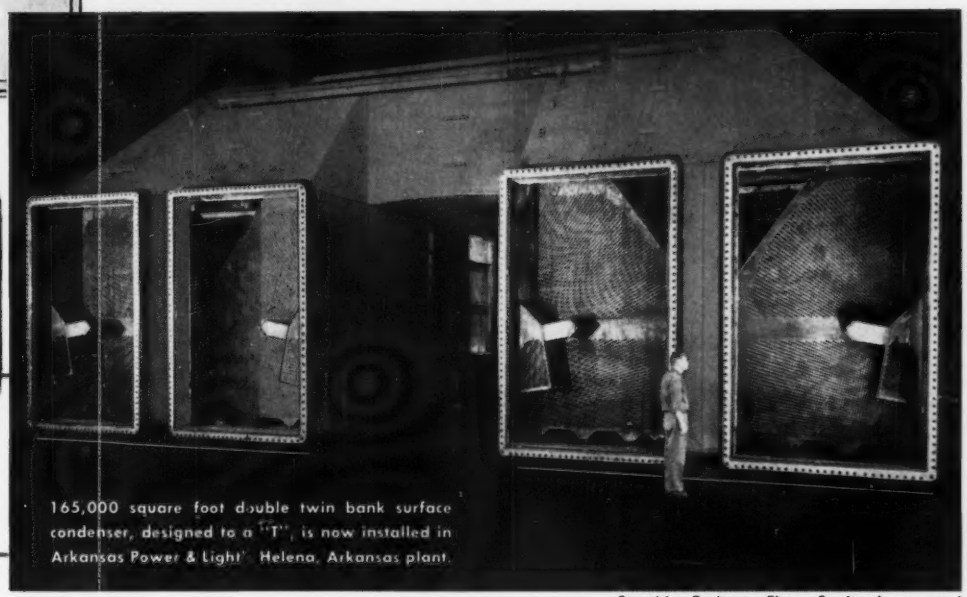
Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200°F. They can be cut, fitted and modified easily in the field without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan, Dept. 1573DW12.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan

For more facts circle 227 on Reader Service card, p 117



YUBA CONDENSERS
ANY SIZE . . . ANY ARRANGEMENT



165,000 square foot double twin bank surface condenser, designed to a "T", is now installed in Arkansas Power & Light's Helena, Arkansas plant.

Consulting Engineers: Ebasco Services Incorporated

MOST VERSATILE TUBE BANK LAYOUT IN THE INDUSTRY

YUBA SURFACE CONDENSER DESIGN . . . most flexible . . . any size . . . any arrangement. Through design advances such as those incorporated in the unit above, Yuba illustrates the concepts you can expect from years of engineering leadership in the power industry.

Yuba's twin-bank tube layout, seen here in a two shell "T" type installation, promotes unobstructed, equally distributed flow. Through Yuba's patented design, the condensate can be deaerated with oxygen content guaranteed to be less than 0.005 cc per liter.

As a design extra, Yuba staggers the tube support plates – reducing harmonics – eliminating vibration. These are some of the reasons why Yuba surface condensers of all sizes have been installed in plants throughout the world. You'll want to know more about the most versatile tube bank layout in the industry – contact Yuba today.

Other Yuba products for steam power plants include feedwater heaters, evaporators, expansion joints, cranes, tanks, structural steel erection, and scores of other items.

YUBA

specialists in power plant equipment

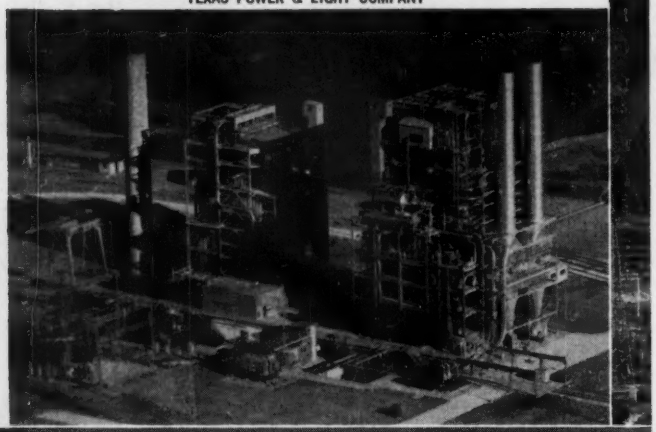
YUBA HEAT TRANSFER CORPORATION

Tulsa, Oklahoma
Plants in Tulsa and Honesdale, Pa.

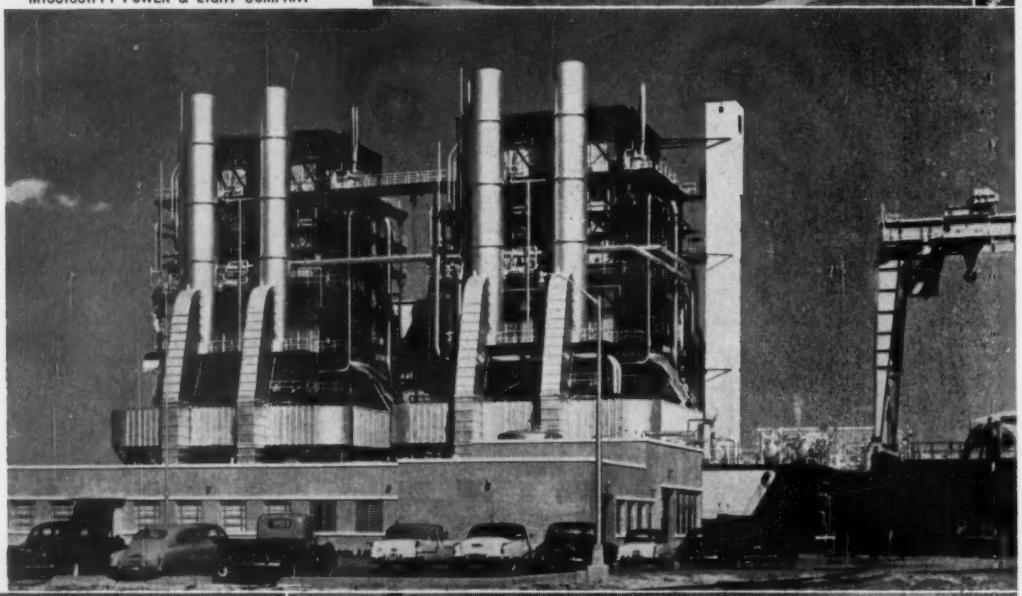
YUBA CONSOLIDATED INDUSTRIES, INC.

Sales Offices in Principal Cities

TEXAS POWER & LIGHT COMPANY



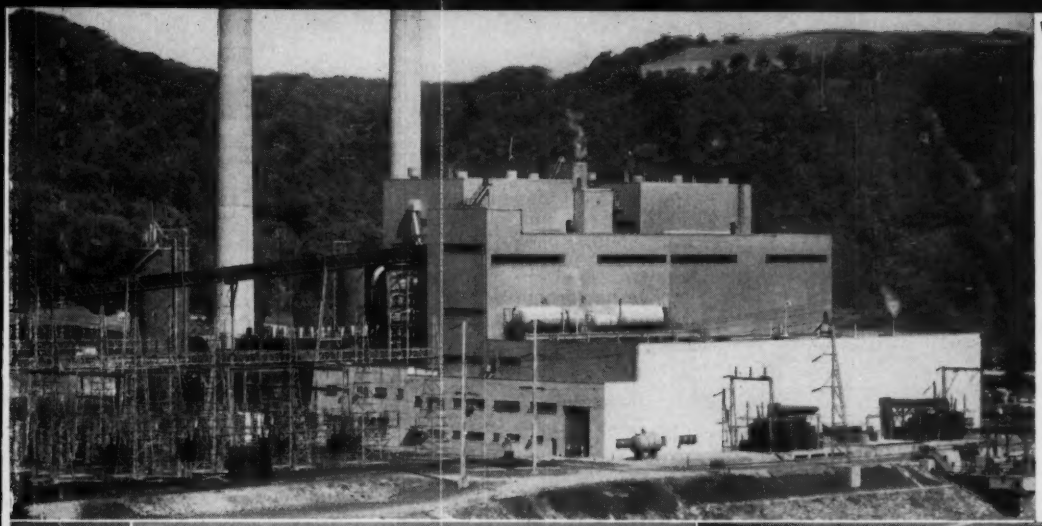
MISSISSIPPI POWER & LIGHT COMPANY



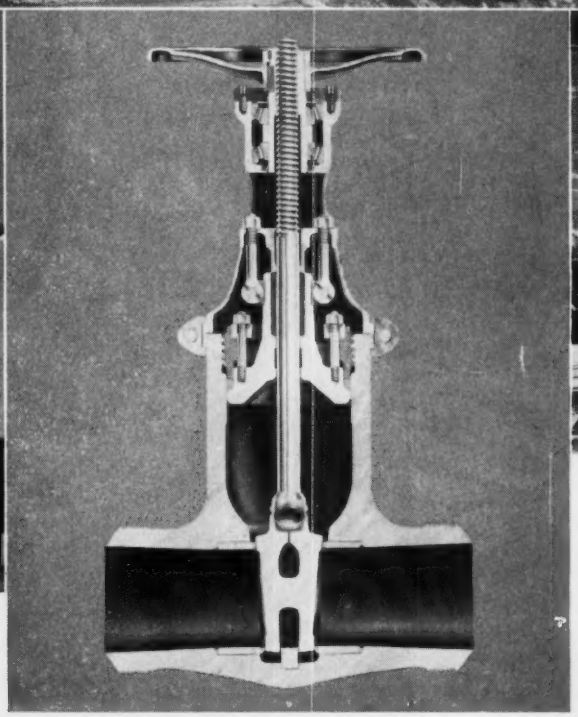
ARKANSAS POWER & LIGHT COMPANY

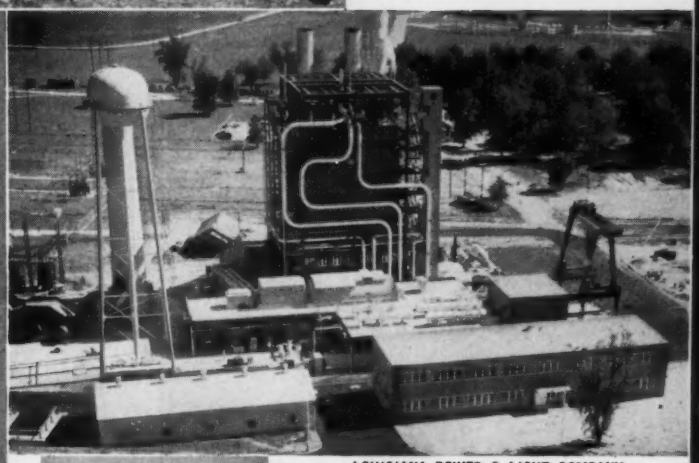
MINNESOTA POWER & LIGHT COMPANY

For more facts circle 229 on Reader Service card, p 117

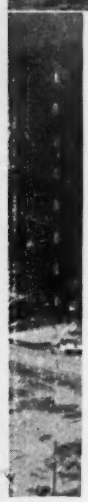


WEST PENN POWER COMPANY





LOUISIANA POWER & LIGHT COMPANY



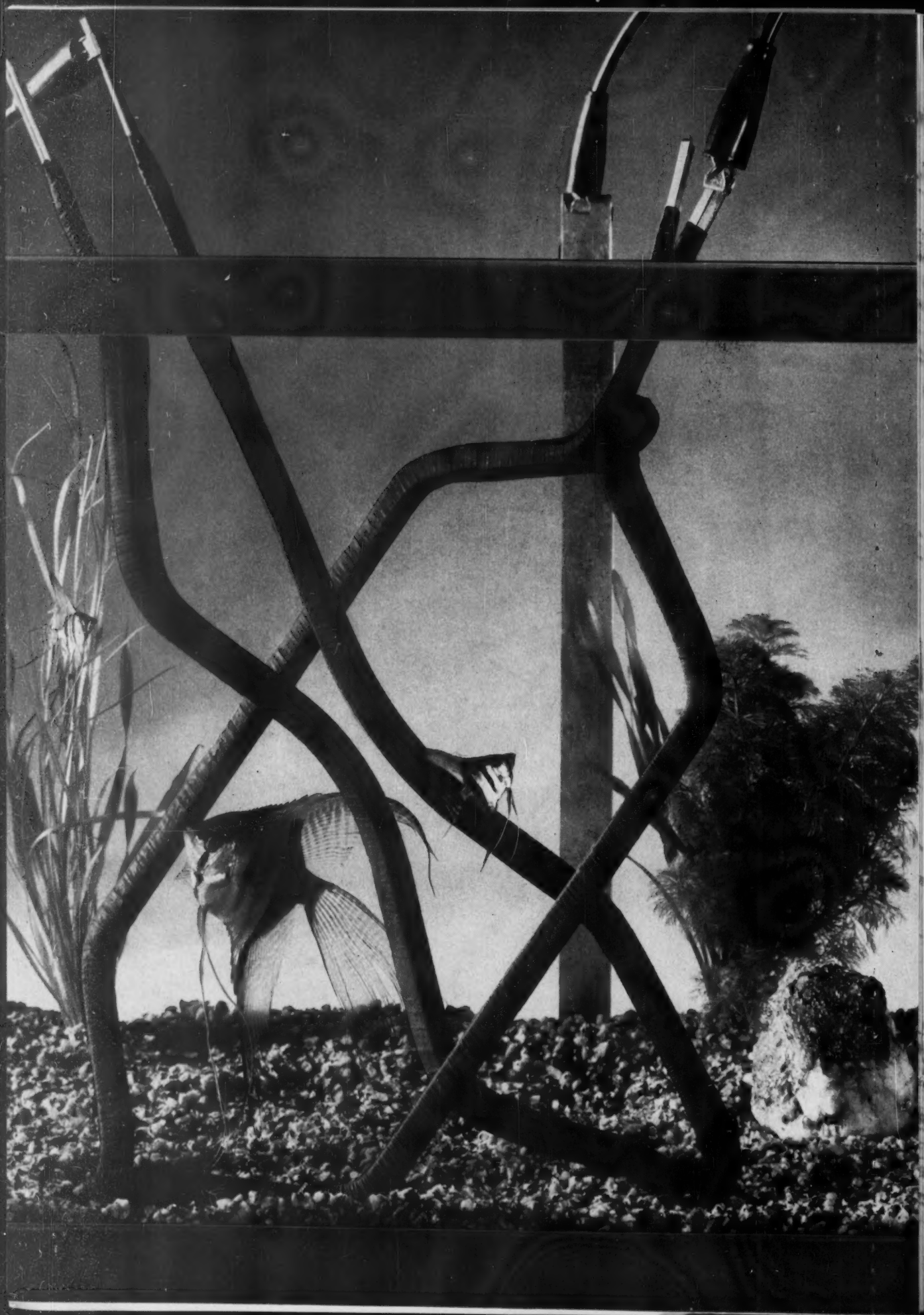
Power plants, coast to coast, rely on

WALWORTH

Pressure - Seal cast steel valves

Power is going up! 39,153 Mw of new steam power are on drawing boards now. ■ Who will make the valves to control this torrent of steam? Walworth, of course, with Pressure-Seal Valves...also bronze, iron, steel valves...all types and sizes...for every steam plant application. ■ Wherever you must control fluid flow—remember Walworth. See your distributor. Walworth, 750 Third Avenue, New York 17, N. Y.

WALWORTH SUBSIDIARIES: Alloy Steel Products Co. ■ Conoflow Corp ■ Grove Valve & Regulator Co. ■ M&H Valve & Fittings Co. ■ Southwest Fabricating & Welding Co., Inc.



Can Your Motor Coils Pass This Test?

E-M Sealflex...

the exciting new flexible epoxy insulation system does!

Sealflex is fully sealed and flexible to provide you with a worry-free coil insulation that protects against water, salt air, dirt, oil, chemicals, solvents and carbon black.

The motor coils on the opposite page are wound with Sealflex. One coil is an undistorted, normally formed coil. The other is bent into a figure 8 to demonstrate the extreme flexibility of the insulation. These 2300-volt coils successfully underwent a water immersion test at more than three times rated voltage! We know you won't be operating your E-M Motor or Generator in an aquarium, but this test demonstrates how a machine of Sealflex-protected coils can minimize your insulation worries.

This amazing, *flexible epoxy* form wound coil insulation system is the result of an extensive, long time program of sealed insulation research between the Irvington Division of Minnesota Mining & Manufacturing Co. and the Electric Machinery Mfg. Company. Fibremat* brand, a flexible B-Stage epoxy insulation, is a product of the world renowned tape research and fabrication facilities of the Minnesota Mining organization. The Sealflex coil is the product of E-M's team of skilled insulation experts . . . backed by more than 60 years of insulation know-how.

Fully-Sealed Protection

Sealflex is a completely sealed system. Each coil is precision wrapped with the newly developed, self-sealing, flexible B-Stage epoxy "Fibremat" brand tape. Curing at 400 F produces a thick, molded-on, tough sheath of high-dielectric strength insulation.

This full sealing, plus the stable characteristics of the epoxy base, make Sealflex especially resistant to tough ambients such as moisture, salt air, dirt, oil, solvents, chemicals, black liquor and carbon black.

Flexible for Long Coil Life

The resilience and toughness of Sealflex is permanent . . . permits the coils to flex with starting loads and to withstand repeated elongation and contraction due to changes in operating temperature. There is no tendency to brittleness and fracturing previously experienced with ordinary epoxy-base insulations.

The abrasion resistance of this new insulation is superior to conventional Class B materials. And its excellence in high dielectric strength and thermal stability contribute to increased reliability and long coil life.

Minimum Upkeep

Because of the super-sealing and moisture-resistant characteristics of Sealflex, there is no need to dry out the machine before startup after a prolonged shutdown. Maintenance is further reduced by the smooth epoxy hide which resists penetration of dust, dirt, and carbon black particles. It cleans easily with air hose or cloth and solvent.

Another first from E-M . . . Sealflex . . . a complete, integrated system designed to provide you with worry-free machine insulation for 130 C (Class B) service in the 600, 3000, and 5000 volt classes.

Get Your Free Brochure

Find out more about the Sealflex System in a new brochure that tells how modern chemistry and modern insulation research made E-M Sealflex best for *flexible*, fully-sealed coil protection from the especially tough ambients involving water, steam, humidity, salt air, dirt, oil, solvents, chemicals, black liquor and carbon black. Ask your nearest E-M Sales Engineer for your copy, or write directly to Electric Machinery Mfg. Company, Minneapolis 13, Minnesota.

*A registered trademark of the Minnesota Mining & Manufacturing Co., St. Paul 6, Minn.

Specialists in making insulation do exactly what you want it to

E-M

200-TPA-2224

Induction Motors • Synchronous Motors • Motor-Generator Sets
High-Cycle Generator Sets • Water Wheel-Driven A-C Generators
Adjustable-Speed Magnetic Drives • Engine-Driven A-C Generators
Turbine-Driven A-C Generators • Motor Controls • Generator Switchgear

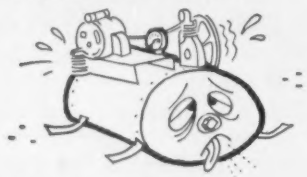
ONE OF A SERIES OF CHATS ABOUT THE CONSERVATION AND CONTROL OF HEAT

SARCO TOPICS

PREVENTION OF CRUELTY TO OLD COMPRESSORS

You've got at least one air compressor, of course. Doesn't everybody? And there it sits, pumping its heart out for you year in and year out. And you there, Simon Legree, do you ever give it a break and measure its capacity?

One measure is the useful work done by your compressed air tools, of course. However, this yard stick may make your compressor installation seem way oversize, but don't blame the equipment. The puffing oldster isn't responsible for choked intake filters, poorly designed suction pipes,



overcooling, undercooling, inadequate distribution mains and wet air. All these things can cost you.

Off and on we're going to talk about compressors in these pages, if you don't mind. It's a big subject and the lesson for today will be confined to the air intake. Can you imagine a more logical place to start?

Where to locate the intake? Easy. Where the atmosphere is clean and cool and dry. Dirty air and grit choke filters and eventually get through to cause wear. The cooler the air; the more you can compress per revolution. You'll get 10% more air delivered at 40°F. than at 90°F. And dryness is imperative, because compressed air can't contain all the moisture it can hold in its uncompressed state. Where does the moisture go? Into mains, tools, and valves, unless it's removed. And need we add that chemical fumes cause corrosion? That includes exhaust gases from engines and furnaces. CO_2 in the presence of oxygen and moisture can rust your valves, tools, nozzles and sprays.

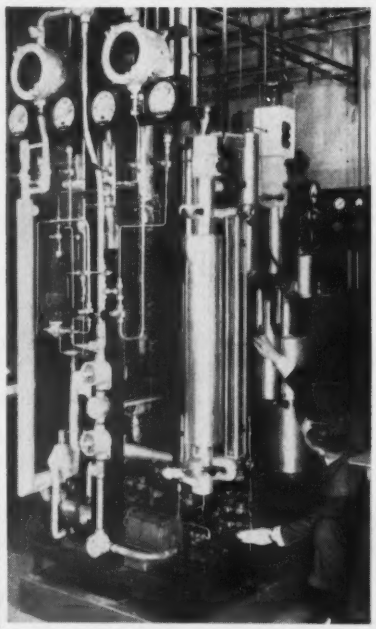
How about intake size? Keep pipes short, sized right, and straight as possible. Small pipes with snaky bends reduce pressure and capacity. For an educated example, a pressure loss due to friction in the intake pipe and filter of 2 psi (14.7 to 12.7) will reduce output of a 125 psi compressor by 7.5%.

How do we know so much? Well, as we continue in future issues, we'll be talking drains and traps and cooling and safety controls for compressors—all of which we manufacture. That's how we know so much. If you can't bear to wait, just write. It's that easy to get information out of us.

SARCO AND THE FLYING DUTCHMAN

In the pipe shop of a major office building complex on New York's east side, the Flying Dutchman flies again. This is really a bright idea which could well become standard practice elsewhere, because it's the kind of logical precaution that would make sense anywhere.

The chap in our photograph is putting together, according to precise, dimensioned drawings, an assembly consisting of a Sarco Thermo-Dynamic Steam Trap, Type TD-50, a Sarco strainer, and valves and fittings for stock. The assemblies will be used for quick and easy replacement in the event of failure or any possible maintenance requirement in the steam distribution system, the heating system, or the air conditioning system.



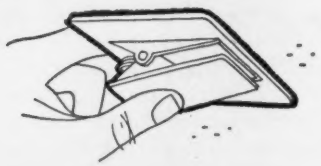
WORLD'S LARGEST ESPRESSO MACHINE?

No indeedy. It's a pilot plant Hydrofiner unit built by The Lummus Company at its Engineering Development Center in Newark, New Jersey. And its presence here is due to the fifteen ⅜" Sarco Thermo-Dynamic Steam Traps which vent and drain its 35 pound tracer lines plus a ½" TD-50 as a main drip. Nice to be picked for projects like this. Makes us proud.

We'd like to be able to report that this plan recently saved thousands of people from freezing or roasting during a crisis. So far, however, the assemblies have proved to be an ornamental kind of insurance policy. Alas, there have been no failures. That dog-goned Sarco performance is just too reliable for its own good.

WE'VE GOT THINGS TO GIVE AWAY

First of all, we have a new spring clip to hold together a bunch of papers on your desk, or something. It's not complicated, but it *is* difficult to describe, so we've gone to the tremendous expense of having our local Michaelangelo sketch it here. If you have no papers to hold together, it makes a rather delightful snapping noise that might amuse you. Oh yes—it also has a cross section of a TD-50 steam trap printed on it which actually *moves* when you wiggle your eyeballs at it. In case you *still* don't know how a TD-50 works, this is for you.



Second, we've still got engineers' sketch pads which we enjoy giving away so much we're offering them again. In case you're new here (Hello!) they contain isometric grid paper for use by anyone involved in piping or hookup sketches for process or heating applications.

And the famous Sarco key chain, which is really exactly that—a chain—about 60 times as handy as a fat case, we're offering again too. This has a TD-50 replica attached, but detachable. Call it tawdry promotion if you will, but our super-aesthetic wife wears one proudly around her neck.

All of these are available from your Sarco representative. Or, if he's out, write in.

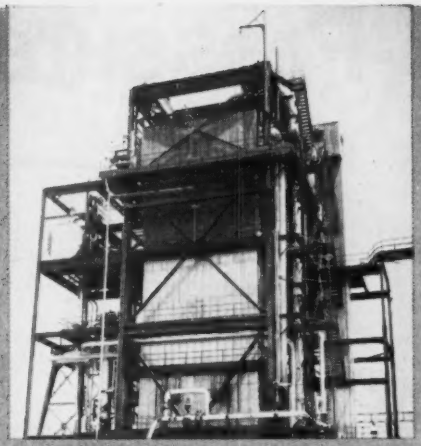
There's really no reason to keep this conversation one-sided. After all, we're both interested in these subjects or you wouldn't have read this far. So write, even if it's only about a difficult problem. 7826

SARCO COMPANY, INC., 635 MADISON AVE., NEW YORK 22, N.Y.

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES

SARCO

since 1948...
continuous expansion
at
Central Louisiana Electric
piped by Midwest



Coughlin Station

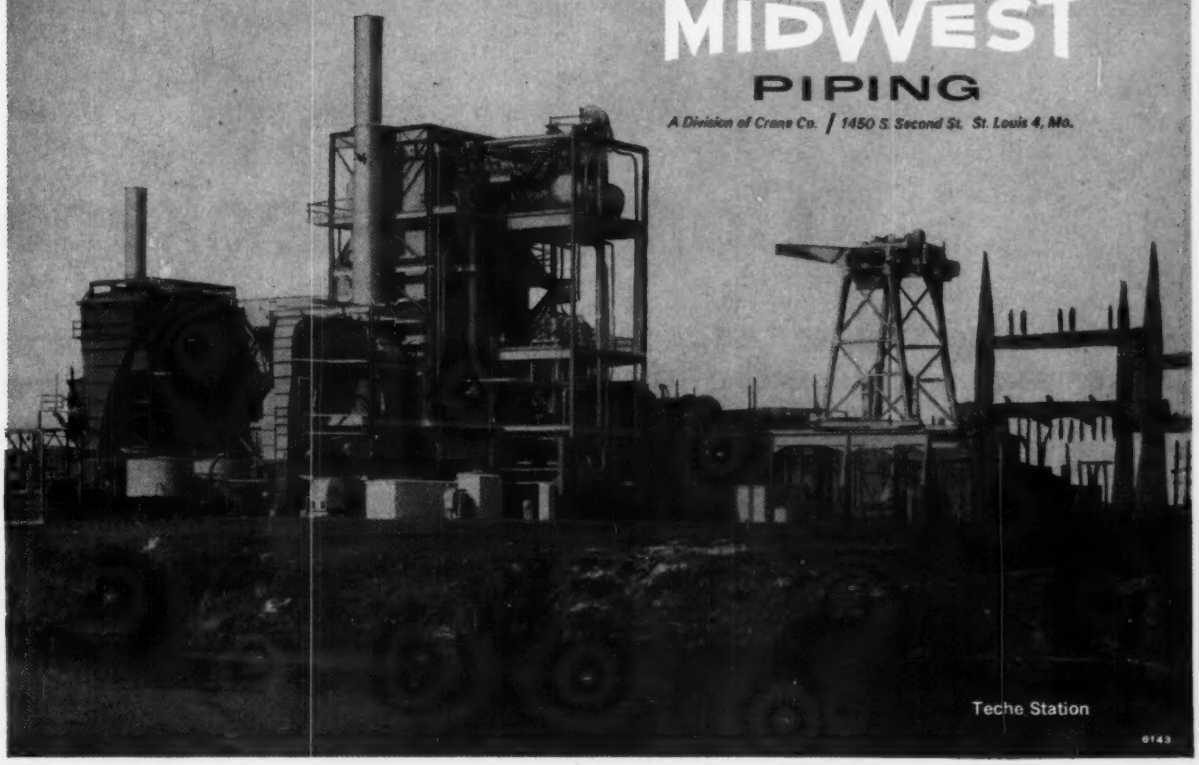
In 1948, Midwest fabricated and erected the piping for Central Louisiana Electric Company's Coughlin Station, Units 1 and 2. Total capacity for both units was 7,500 KW, operation conditions 625 pounds @ 825°.

Midwest continued to furnish piping for the station's four subsequent expansions, including a 100,000 KW unit in 1961, and for the first two units of the company's Teche station. Combined capacity of all units piped by Midwest was 270,000 KW.

Midwest's proven capabilities for quality fabrication and erection have resulted in "repeat business" like this from many major power companies.

The story of Midwest's coordinated fabrication-erection service is told in a 24-page illustrated brochure, POWER AND PROCESS PIPING. Write for your free copy today.

MIDWEST
PIPING
A Division of Crane Co. / 1450 S. Second St. St. Louis 4, Mo.

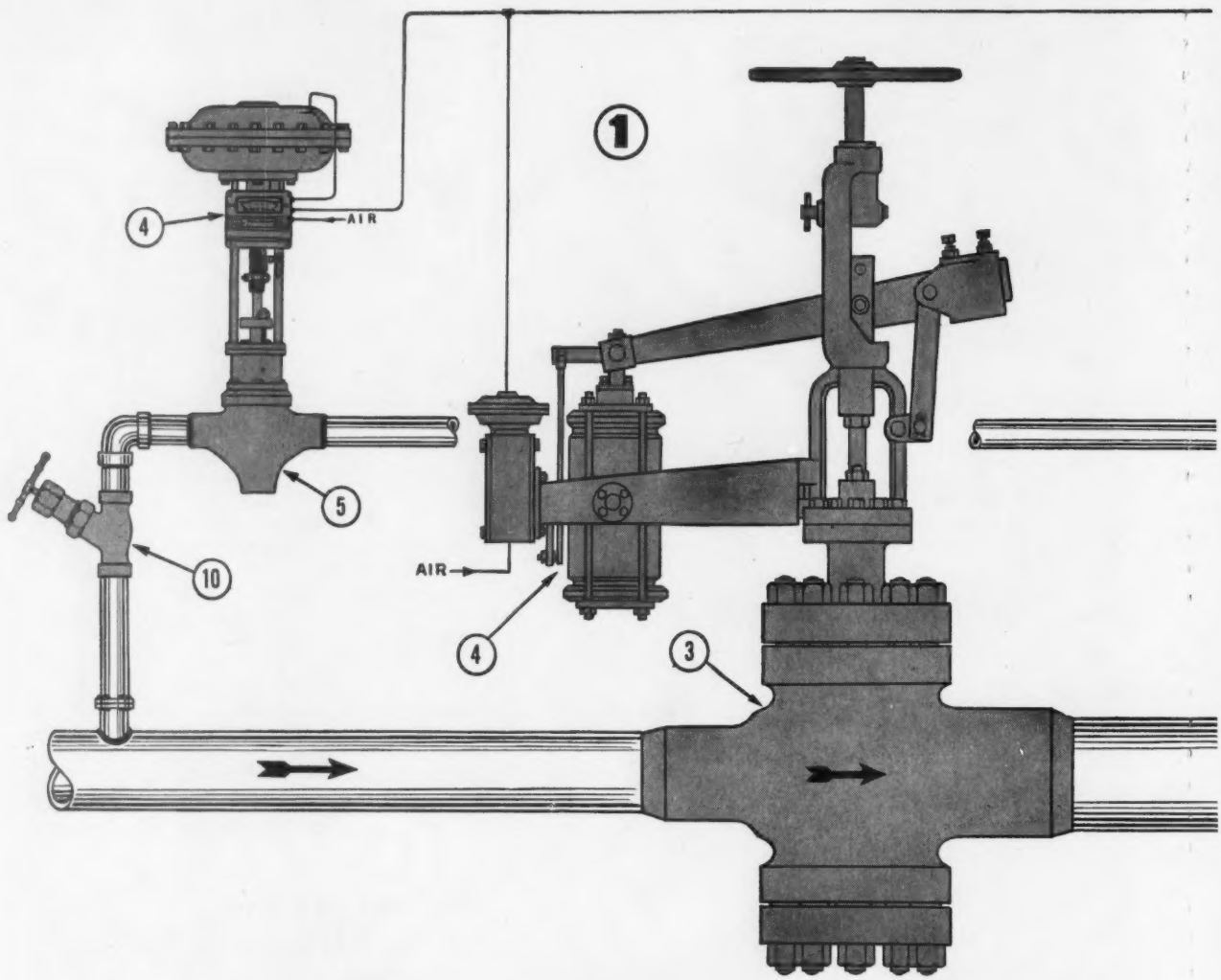


Teche Station

6143

For more facts circle 232 on Reader Service card, p 117

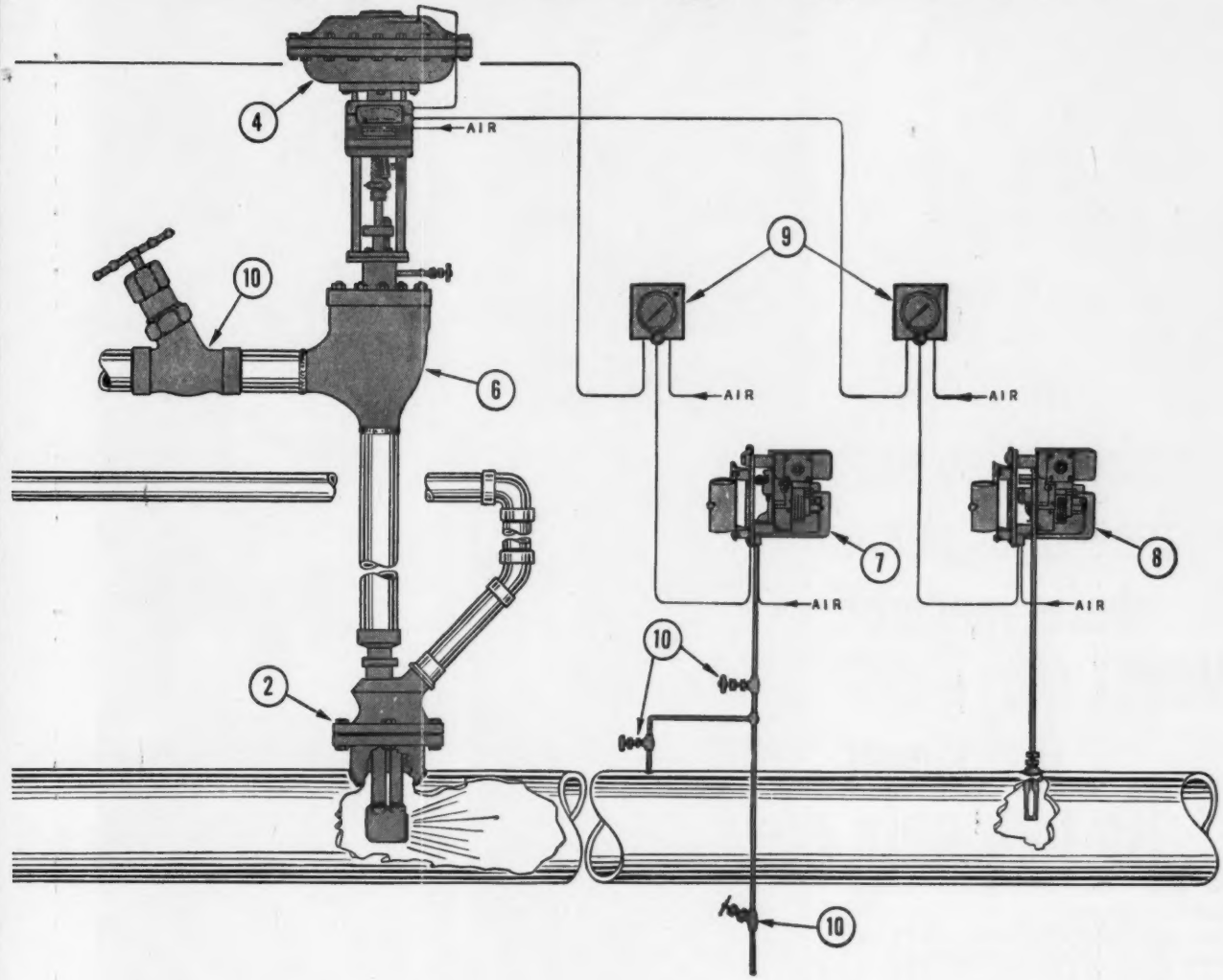
Pressure Reducing and



Complete package

① SYSTEM ENGINEERING BY _____
② STEAM ATOMIZING DESUPERHEATER BY _____
③ PRESSURE REDUCING VALVE BY _____
④ POSITIONERS AND DRIVE UNITS BY _____
⑤ ATOMIZING STEAM CONTROL VALVE BY _____
⑥ WATER FLOW CONTROL VALVE BY _____
⑦ PRESSURE CONTROLLER BY _____
⑧ TEMPERATURE CONTROLLER BY _____
⑨ CONTROL STATIONS BY _____
⑩ STOP AND BLOW-DOWN VALVES BY _____

Desuperheating System



from one source:

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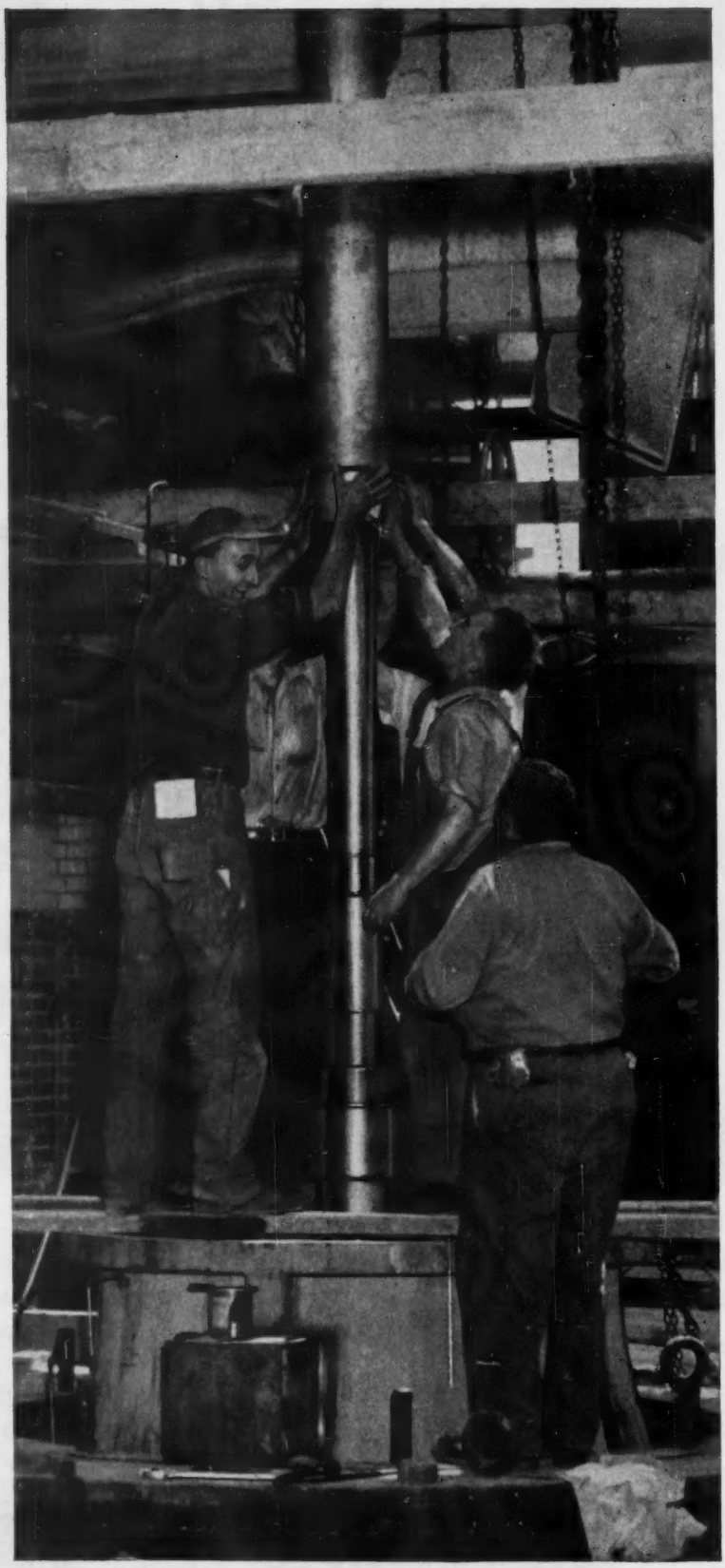
For full details on how a Rockwell-Republic pressure reducing and desuperheating system can benefit you, contact the Republic Engineer in your area. Or, write to Republic Flow Meters Company, Subsidiary of Rockwell Manufacturing Company, 2240 Diversey Parkway, Chicago 47, Illinois. In Canada: Republic Flow Meters Canada Ltd., Toronto.

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
ROCKWELL

For more facts circle 233 on Reader Service card, p 117



Here's why circulating and feedwater pump shafts made of MONEL Alloy K-500 last longer

MONEL* alloy K-500 (formerly sold as "K" Monel alloy) has a unique *combination* of properties ideally suited to meet the shaft requirements of circulating and feedwater pumps. These properties include:

- **High strength,** toughness, and torsional properties for transmitting power with minimum vibration.
- **Hardness** to resist abrasion and scoring. This means prolonged shaft and bearing life.
- **High fatigue resistance** to the repeated stresses that high-speed pump shafts must undergo.
- **Resistance** to corrosion and corrosion-fatigue in sea or brackish water.
- **Galvanic neutrality** when coupled with bronze pump bodies and bearings.

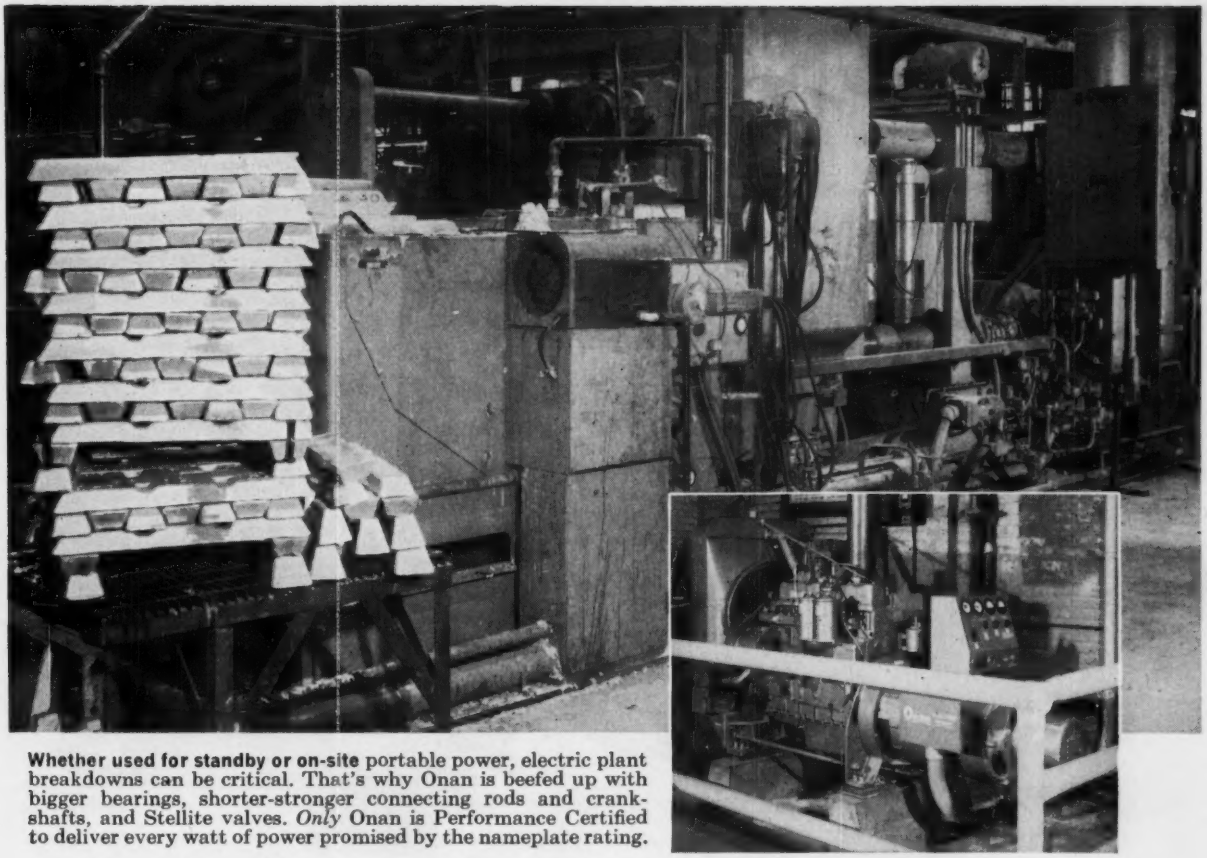
For information about how MONEL alloy K-500 shafts provide dependable, long service in power applications, send for our Technical Bulletin T-9 and folder, "Practical Answers to Pump Problems." Just write to:

*Registered trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17 West Virginia

INCO

MONEL
NICKEL-COPPER ALLOYS



Whether used for standby or on-site portable power, electric plant breakdowns can be critical. That's why Onan is beefed up with bigger bearings, shorter-stronger connecting rods and crankshafts, and Stellite valves. *Only* Onan is Performance Certified to deliver every watt of power promised by the nameplate rating.

Only Onan is certified to give you all the power promised by its nameplate

It's a fact that many electric plants on the market today do not deliver the output promised by their nameplate rating.

Every Onan plant is given a rugged workout *under full load* before it is shipped—*your assurance* that the Onan you buy is ready for hard work the day you get it.

But this isn't enough. Independent laboratory inspectors pull surprise inspections to double-check our tests and testing methods. They pull a plant off the line, run it, stop it, load it, overload it, check and recheck. Their torture test gives positive proof of Onan's quality. End result: *Onan's exclusive Performance Certification* . . . your assurance of getting every watt of power you pay for.

So when you're tempted by an electric plant "bargain," make sure its nameplate rating is not "inflated." Be sure you're getting full measure for your money. Remember, *the electric plant that short-changes you in power output is no bargain at any price!* Only Onan is Performance Certified to deliver everything the nameplate promises.

See Onan electric plants soon. Compare before you buy. You'll find your Onan distributor listed in the Yellow Pages. Call him or write direct.

PERFORMANCE CERTIFIED
We certify that when properly installed and operated this Onan electric plant will deliver the full power and the voltage and frequency regulation promised by its nameplate and published specifications. This plant has undergone several hours of running-in and testing under realistic load conditions, in accordance with procedures certified by an independent testing laboratory.
Onan
Onan

World's Leading Builder of Electric Power Plants

Onan

ONAN Division, Studebaker-Packard Corporation, 2687 University Ave. S. E., Minneapolis 14, Minn.

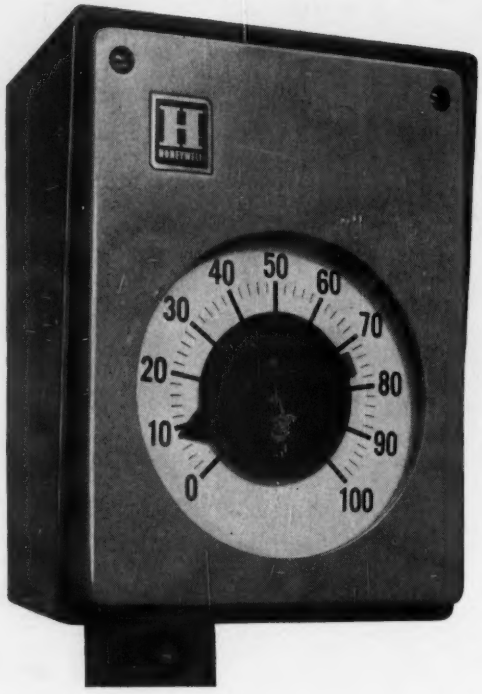
For more facts circle 235 on Reader Service card, p 117

NEW HONEYWELL TRANSMITTERS

New pneumatic bellows flow transmitter

gives all the economy and convenience of pneumatic transmission and all the efficiency of the bellows meter body with the added option of field indication. The transmitter has 16 ranges (0-10 to 0-400 inches of water) and is used to transmit flow or liquid level measurements in open or closed tanks.

Transmitter Features: Make range changes in the field simply by replacing a single spring assembly. You can adjust damping quickly and accurately while the instrument is in operation. You can install meter with vertical or horizontal piping, so that it vents, drains and purges itself.



New pneumatic temperature transmitter

offers thermal system options with ranges from −125° to 1000°F. Completely new, completely flexible, this transmitter gives you a choice of either mercury or gas actuated thermal system with a wide selection of measuring bulb styles.

Transmitter Features: Mount transmitter on a pipe welded to flow line or on a bracket that clamps to hex head of socket. Vibration resistant thermal system means accurate measurement on vibrating flow lines.

Added Features of both transmitters are: automatic ambient temperature compensation; two-way overload protection (100% of span on temperature transmitters, 100% of rated meter body pressure on bellows flow transmitters); modular construction for simplified maintenance; self-locking feature to prevent upset; die-cast aluminum case 4″ x 7″ x 9″; available with concentric scale or as non-indicator; transmission accuracy ±0.5% full scale; accuracy of indication ±1% full scale.

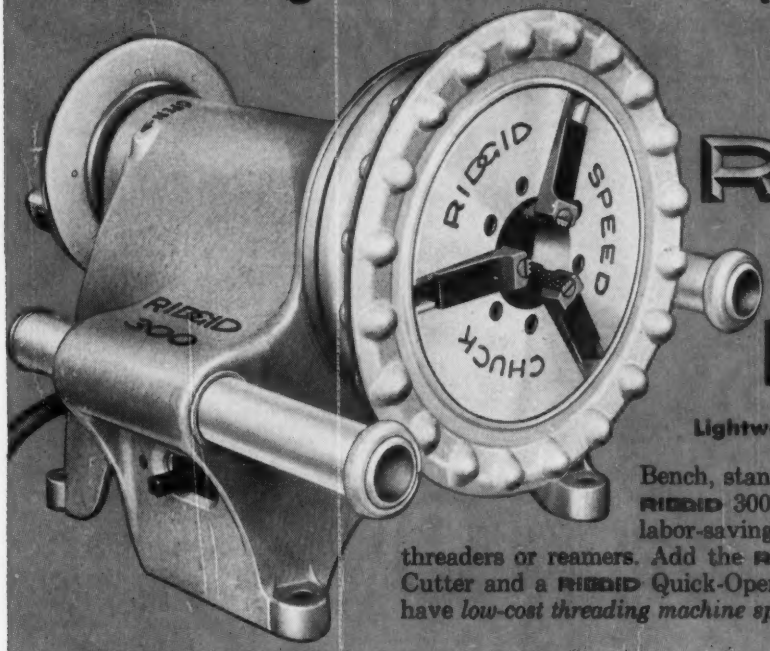
For more complete details on the new temperature and bellows flow transmitters, call your nearby Honeywell field engineer. Or write MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

H HONEYWELL SINCE 1885 *First in Control*

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Time-Saving Power For Your Shop or on the Job...



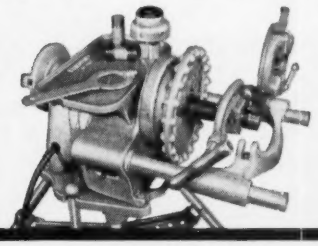
New RIDGID 300 Power Drive

Lightweight • Versatile • Low in Price

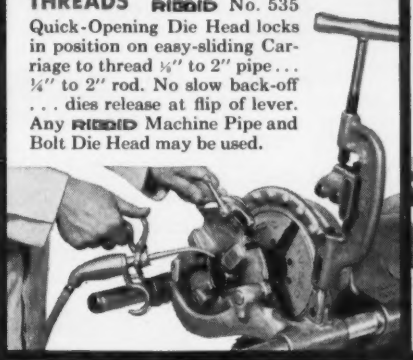
Bench, stand or truck mounted, this compact RIDGID 300 Power Drive gives you time and labor-saving power for your hand cutters, threaders or reamers. Add the RIDGID No. 310 Carriage, No. 360 Cutter and a RIDGID Quick-Opening Machine Die Head, and you have *low-cost threading machine speed and ease!*

Here's What it Does!

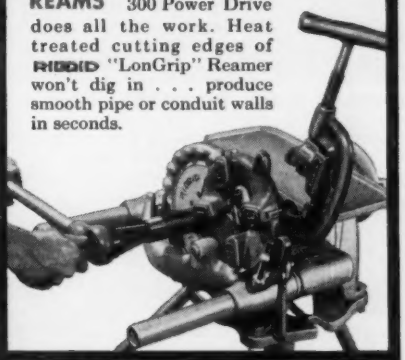
CUTS RIDGID No. 360 Cutter, shown here, cuts ⅛" to 2" pipe and conduit — up to ⅝" rod. Extra-wide rolls keep cutter straight for perfect high-speed tracking. Cutter stays back out-of-way when not in use.



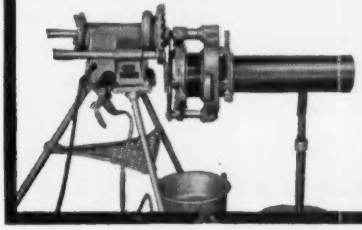
THREADS RIDGID No. 535 Quick-Opening Die Head locks in position on easy-sliding Carriage to thread ⅛" to 2" pipe... ¼" to 2" rod. No slow back-off ... dies release at flip of lever. Any RIDGID Machine Pipe and Bolt Die Head may be used.

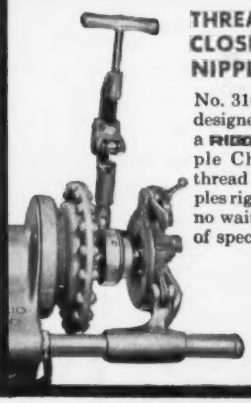


REAMS 300 Power Drive does all the work. Heat treated cutting edges of RIDGID "LonGrip" Reamer won't dig in . . . produce smooth pipe or conduit walls in seconds.



DRIVES GEARED THREADERS Compact, RIDGID No. 300 Power Drive has plenty of power for up to 12" geared tools. New RIDGID Close-Coupled drive shown here, for Nos. 141 and 161 Jam-Proof Threaders eliminates Universal Drive Shaft . . . saves working space.





THREADS CLOSE NIPPLES

No. 310 Carriage is so designed that by using a RIDGID No. 19 Nipple Chuck you can thread even close nipples right on the job... no waiting for nipples of special lengths.

AND IS EASY TO MOVE With the aid of the Transporter, one man can easily move a RIDGID 300 Power Drive with its No. 1206 Folding Stand attached. Set-up is fast and easy. Stand's integral tool tray locks legs in position, forming rigid work base.

Save Time and Increase Your Profits on Every Job. See and Try This Biggest "Threading Machine" Bargain at your Supply House!

RIDGID

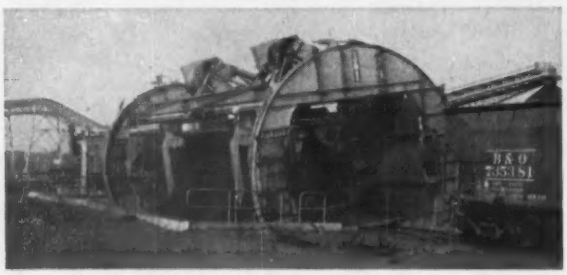
The Ridge Tool Company, Elyria, Ohio, U.S.A.

For more facts circle 237 on Reader Service card, p 117

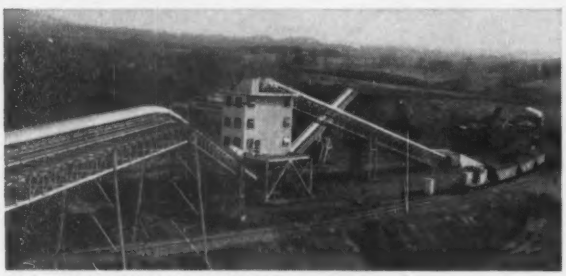
a coal handling system with

NO "GROWING PAINS"

DICKERSON GENERATING STATION of Potomac Electric Power Company was engineered jointly by PEPCo and Stone & Webster. It has two coal-fired steam generators, each rated 185,000 kw. The expandable Link-Belt coal handling system currently handles 750 tph.



UNLOADING IS FAST AND EFFICIENT with this Link-Belt rotary car dumper. It can empty a 90-ton capacity car in just 60 seconds, exclusive of spotting and removal time. Integral electronic scale weighs cars full and empty to determine load.



COAL RIDES LINK-BELT CONVEYORS from coal cars to power plant bunkers. First stop is the crusher house (center). From here, the minus 1½" coal is carried directly to bunkers or is directed to a Link-Belt stationary boom conveyor for outdoor storage.

DISTRIBUTION TO BOILER BUNKERS is done by a Link-Belt motor-propelled traveling tripper. The tripper operates on T-rail tracks and can be moved back and forth automatically over any one of the bunkers. The control panel is affixed to the tripper itself.

EXPANDABLE Link-Belt system keeps pace with coal handling needs of PEPCo's rapidly growing Dickerson Station

Dickerson Station of Potomac Electric Power Co. went "on line" in 1959, added a 185,000 kw unit in 1960 and will boost capacity again in 1962. A key economy factor in this well-planned expansion program is the plant's Link-Belt coal handling system. With simple, low-cost modifications, the system can be expanded as required. In fact, provisions have been made to *double* the present 750-tph capacity.

This plant is just one example of how Link-Belt coal handling experience and equipment can be put to work for you. *Whatever* your problem, you can count on Link-Belt for a low-cost solution. We will work with your engineers and consultants from planning through erection of your system . . . or will assume complete responsibility for the entire installation. For details, contact your nearest Link-Belt office. Ask for Book 2410.

LINK-BELT

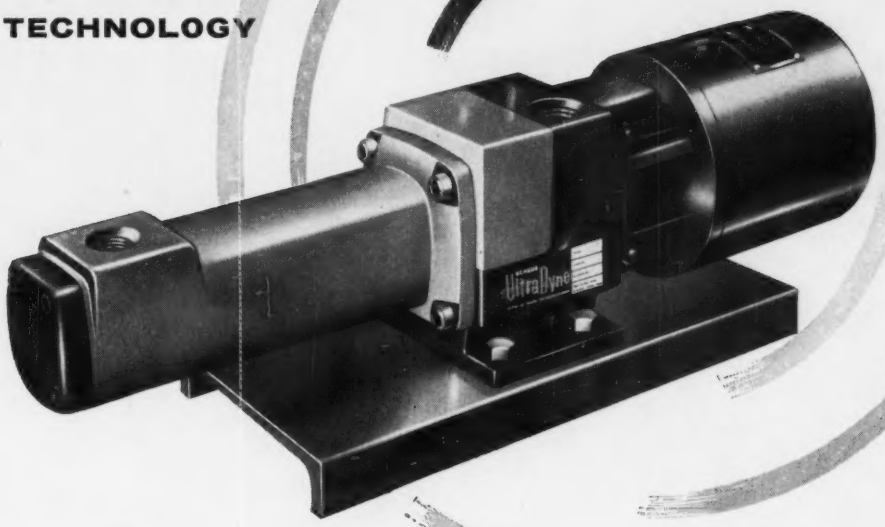
COAL HANDLING EQUIPMENT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses and District Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,969

For more facts circle 238 on Reader Service card, p 117

Introducing a Major Breakthru in

BOILER
FEED PUMP
TECHNOLOGY



Series RCS—close-coupled design

The SCHAUB UltraDyne Multi-Stage Centrifugal

So Advanced It Is

DOUBLE GUARANTEED

FOR 5 FULL YEARS

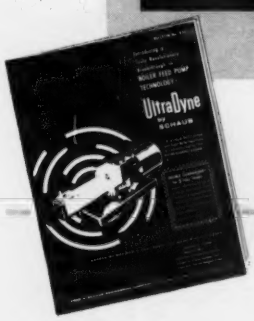
- Against pump mechanical failure or motor burn-out (when close-coupled)
- To retain at least 85% of new pump capacity

Only a revolutionary new kind of boiler feed pump could make this guarantee possible or even believable. There have been excellent centrifugals. There have been fine turbine pumps. But never a pump built to combine the best features and abilities of both—plus a combination of features you could never get before in **any** pump. **For instance:**

- **2-Foot NPSH at all heads in all models—(the UltraDyne handles boiling water with only 2-foot submergence, without vapor bind.)**
- **No cavitation and no motor overload ever.**
- **Substantial installation and operating savings, with smaller motor sizes.**
- **More than a dozen new design features proved in over a million hours of laboratory and industrial field service.**

CAPACITIES 5-150 GPM • HEADS to 700 Feet/ 44 sizes in 3 series.

Available as original equipment only in SCHAUB BOILER FEED and DEAERATION SYSTEMS. Another major step ahead for SCHAUB and YOU. Mail coupon for complete, confirming facts.



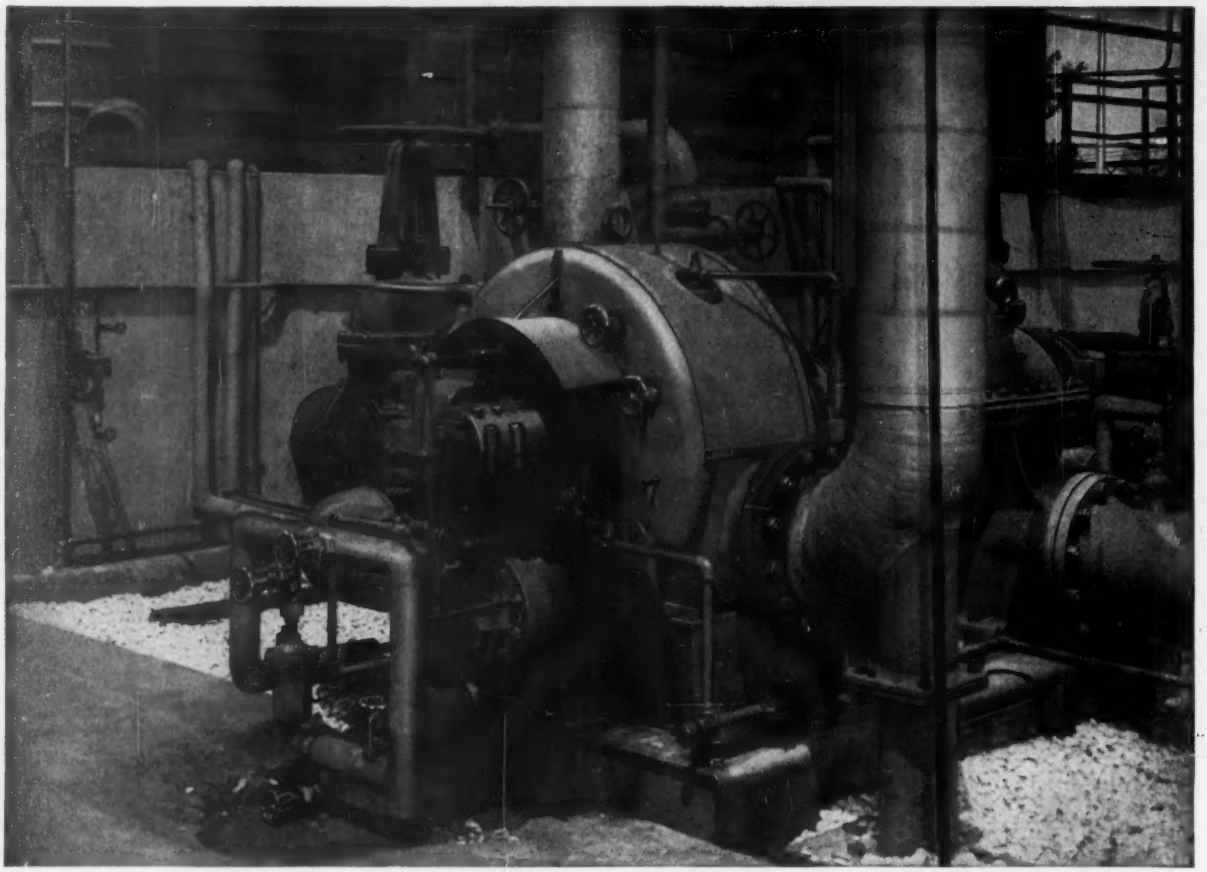
FRED H. SCHAUB ENGINEERING COMPANY
5305 Belmont Road, Downers Grove, Illinois

Please send me my copy of new technical data Bulletin 830 on the Schaub UltraDyne.

NAME.....

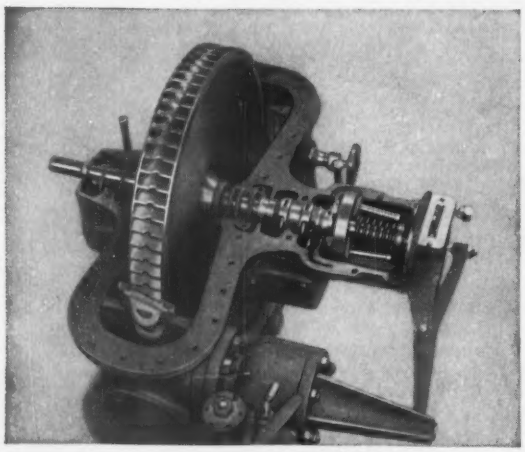
Clip and attach to your letterhead

For more facts circle 239 on Reader Service card, p 117



TERRY SOLID-WHEEL TURBINES

used exclusively at Baton Rouge plant of W.R.Grace & Co.



The upper photograph shows one of the 17 Terry turbines installed at the Baton Rouge, La., GREX high-density polyethylene plant of W. R. Grace & Co. Above, a typical Terry solid-wheel turbine with cover removed to show the wheel construction.

In purchasing equipment for their new 50,000,000-pound high-density polyethylene plant, W. R. Grace & Co. standardized, wherever possible, on a single source of supply for each type of equipment used. Consistent with this policy, Terry steam turbines were used exclusively throughout the utility and process sections of the plant.

A total of 17 turbines were placed in service for driving pumps and fans. These are all of the solid-wheel type, ranging in capacity from 50 to 240 HP.

Terry solid-wheel turbines are known for their long life and sure dependability under the most-trying operating conditions. They feature a single-piece wheel which is virtually indestructible.

Send for details of these trouble-free turbines. Ask for a copy of bulletin S-116.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

TT-1214

YARWAY news briefs

from **Yarnall-Waring Company,** *Philadelphia 18, Pa.*

BRANCH OFFICES IN 19 UNITED STATES CITIES • SALES REPRESENTATIVES THROUGHOUT THE WORLD

PROVEN DEPENDABILITY

MORE THAN 16,000 INSTALLATIONS ATTEST TO SUCCESS OF YARWAY REMOTE LIQUID LEVEL INDICATORS

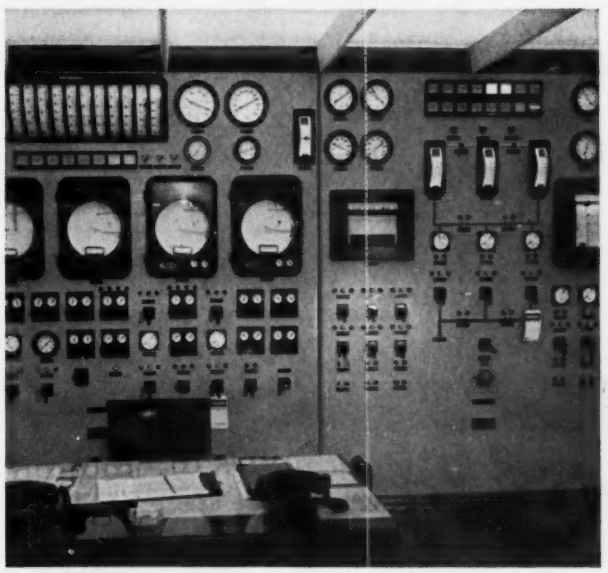
Widespread use of remote liquid level indicators for boiler water level applications, many within ASME Boiler Code requirements as they pertain to installations over 900 psi, have focused attention on the outstanding service record of Yarway Indicators.

More than 16,000 Yarway Remote Liquid Level Indicators are in successful service throughout industry — hundreds are operating in place of one of two required gage glasses on higher pressure boilers as permitted by the code.

Briefly, these features are responsible for Yarway Indicator's dependability—and success:

- Readings are *instant* and *accurate* because indicator is operated by the boiler water itself
- Pointer mechanism is never under pressure
- Brilliant, wide-vision dial makes readings easy from any point in a 180° arc around the indicator—and at considerable distances

Write for Bulletin RI-1825 (pressures to 700 psi), or Bulletin RI-1826 (over 700 psi).



Four Yarway Remote Liquid Level Indicators installed at new Mid-West utility.

A FEW TYPICAL USERS

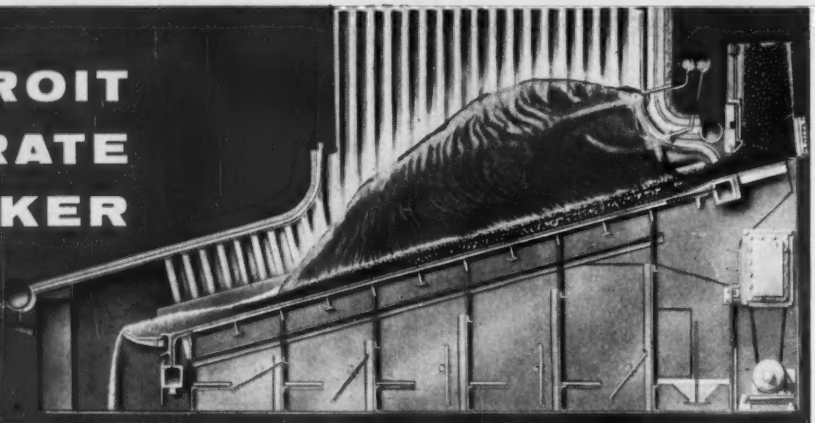
INDUSTRIAL PLANTS
WEYERHAEUSER COMPANY
REPUBLIC STEEL CORP.
FORD MOTOR COMPANY
UNION BAG & PAPER COMPANY
WESTINGHOUSE ELECTRIC CORP.
GENERAL ELECTRIC COMPANY
STAUFFER CHEMICAL COMPANY
WILSON & COMPANY
U. S. STEEL COMPANY
GENERAL MOTORS
MOBIL OIL COMPANY

UTILITIES
CONSOLIDATED EDISON
COMMONWEALTH EDISON
BOSTON EDISON
CENTRAL ILLINOIS PUBLIC SERVICE
PHILADELPHIA ELECTRIC CO.
ILLINOIS POWER CO.
WISCONSIN POWER & LIGHT
CONSUMERS POWER CO. (JACKSON, MICH.)
NORTHERN STATES POWER CO.
PUBLIC SERVICE OF INDIANA
IOWA ELECTRIC LIGHT & POWER
NEBRASKA POWER
NEW ENGLAND POWER
ROCHESTER GAS & ELECTRIC CO.
OMAHA PUBLIC POWER DISTRICT
PUBLIC SERVICE OF COLORADO
LOUISIANA POWER & LIGHT
HARTFORD ELECTRIC LIGHT CO.
POTOMAC ELECTRIC POWER CO.
PENNSYLVANIA POWER & LIGHT
VIRGINIA ELECTRIC & POWER
PACIFIC GAS AND ELECTRIC CO.
DALLAS POWER & LIGHT

For more facts circle 241 on Reader Service card, p 117

DETROIT VIBRA-GRATE STOKER

a natural for institutional plants . . .



THE VIBRA-GRATE STOKER . . .

. . . with its inherent low dust carryover characteristics and resultant clean stack, plus its ability to handle low loads with good efficiency, has a special appeal for campus heating plants, hospitals and similar institutions.

Grate vibration assures automatic continuous ash discharge.

Water cooling of the grate inhibits clinker formation and prolongs the service life of the grates. Other moving parts (none in the furnace) are few, so that total maintenance costs are minimal.

Performance is efficient under either high or low loads—low excess air and low carbon losses.

Not restrictive as to fuel—successfully burns coals of low volatile, low ash fusion or those of high free-swelling index. No moisture tempering is needed.

Overall efficiency and ability coupled with low maintenance have played an important part in the selection of Vibra-Grate Stokers by such well known institutions as:

Berea College, Berea, Ky.
Bucknell University, Lewisburg, Pa.
Central Islip State Hospital, Central Islip, L.I., N.Y.
Cornell University, Ithaca, N.Y.
Maryland House of Correction, Jessups, Md.
Medical College of Virginia, Richmond, Va.
Ontario Hospital, Cedar Springs Ont., Canada
Ontario Hospital, London, Ont., Canada
Pennsylvania State University, University Park, Pa.
Pilgrim State Hospital, Brentwood, N.Y.
Princeton University, Princeton, N.J.
Radford College, Radford, Va.
St. Joseph's Hospital, Marshfield, Wis.
Western State Hospital, Staunton, Va.

District Offices or Representatives in Principal Cities

DETROIT STOKERS

DETROIT STOKER COMPANY
DIVISION OF UNITED INDUSTRIAL CORPORATION

MAIN OFFICE AND WORKS • MONROE, MICHIGAN

For more facts circle 242 on Reader Service card, p 117

In a wet, cold, foreign country

...**Gilsulate** poured-in-place insulation and ...A leading prefabricated steel case piping insulation were tested under identical conditions

Here are the results...

Gilsulate system was less than ½ the cost for the completed installation of the steam and condensate return system.

Gilsulate system had ⅕ the heat loss.

Gilsulate resulted in greatly reduced maintenance costs. Leaks in piping can be easily located and repaired. GILSULATE requires no casing, which is subject to damage and corrosion, to keep it dry.

We will be pleased to send you technical information on GILSULATE insulation so you can evaluate the merits of this low-cost, poured-in-place material. Once you have learned the merits of GILSULATE, we feel certain you will want to write your "specs" to assure the use of GILSULATE... *with engineer-supervised installation.*

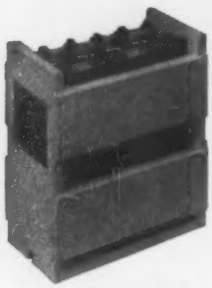
The insulation for superior protection of underground hot pipes

Gilsulate®

American Gilsonite Company | Municipal Airport P. O. Box 15 | Salt Lake City, Utah

Distributors in Principal Countries of the World

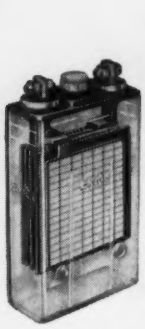
For more facts circle 243 on Reader Service card, p 117



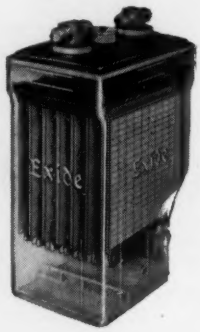
Low-maintenance pocket positive nickel-cadmium

New 20-year Exide-Ironclad tubular with Silvium*

MATCH BATTERY POWER TO YOUR NEEDS AND SAVE MONEY



Flat plate Tytex with Silvium or calcium



Long life Exide-Manchex, Planté type, with Silvium

Trickle or Hi-Lo charger

Constant voltage charger

This is what you get in the Exide Power Package. For your particular application, you need a particular type and size battery for maximum economy. Then you need a particular charger. And you need a certain amount of regular service.

Exide is in the unique position to provide the exact battery, charger and service that your particular application requirements call for. Only Exide offers so broad a line of batteries and chargers. And only Exide has such a well-trained field force of factory supervised service specialists.

An Exide Power Package not only insures you of getting the power you need, but it protects you from overspending on capacity you don't need. And you get everything from one dependable source. It's your easiest, surest way of getting maximum battery power economy. Write for complete information. Exide Industrial Marketing Division, The Electric Storage Battery Company, Philadelphia 20, Pa.

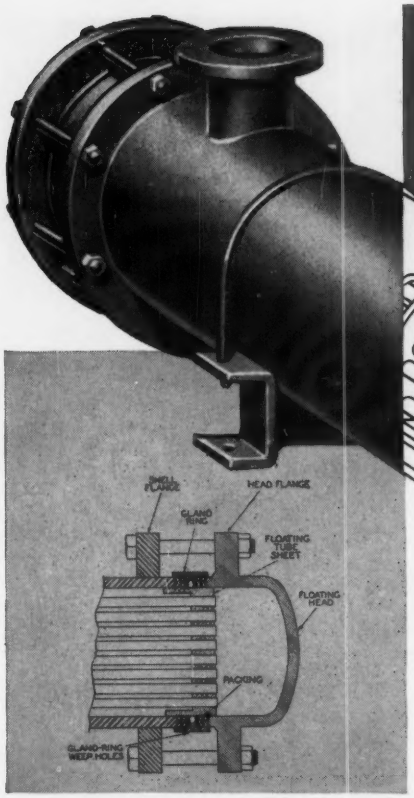
*Silvium is Exide's patented corrosion-resistant grid alloy

Exide®

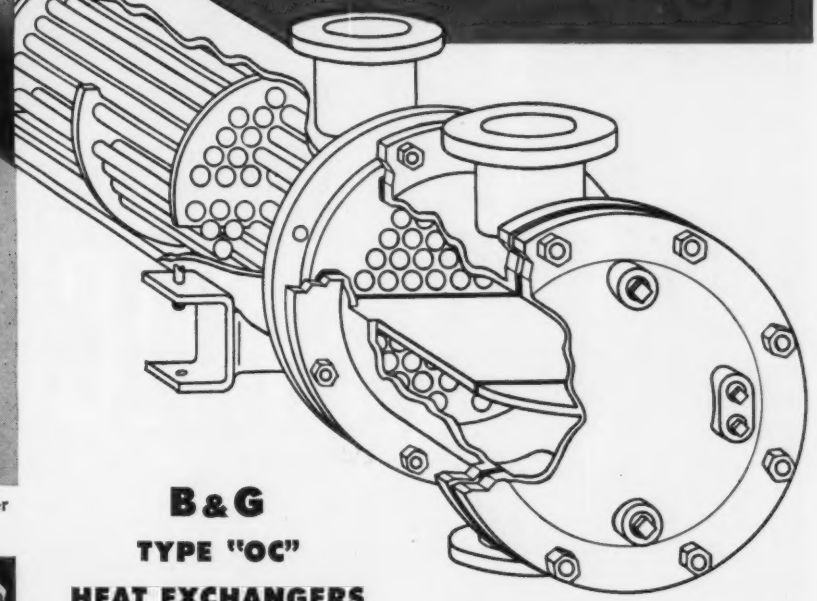
INDUSTRIAL MARKETING DIVISION
The Electric Storage Battery Company

ESB

FOR MORE DEPENDABLE HEATING AND COOLING OF LIQUIDS AND GASES



Cross section of Type "OC" Heat Exchanger showing floating head construction.



B&G TYPE "OC" HEAT EXCHANGERS

B&G Heat Exchangers are welded in specially designed fixtures by expert workmen.

All B&G Heat Exchangers are built to A.S.M.E. Code requirements and are so stamped.

For heating or cooling a wide variety of liquids and gases, "OC" Heat Exchangers offer numerous design and construction features which are a warranty of long life and efficient performance.

These units have removable tube bundles with an internally packed floating head. Sizes range from 6″ through 30″ diameters, lengths from 2′ through 20′. Standard material includes steel shells and tube sheets, cast iron heads and copper tubes. Stainless steel tubes, tube sheets and heads are also available. The design of "OC" exchangers may be varied for channel or bonnet heads in both single and two-pass construction.

B&G "OC" Heat Exchangers are not only engineered to top efficiency but are constructed to the uncompromising standards of quality and safety demanded by the A.S.M.E. Code.

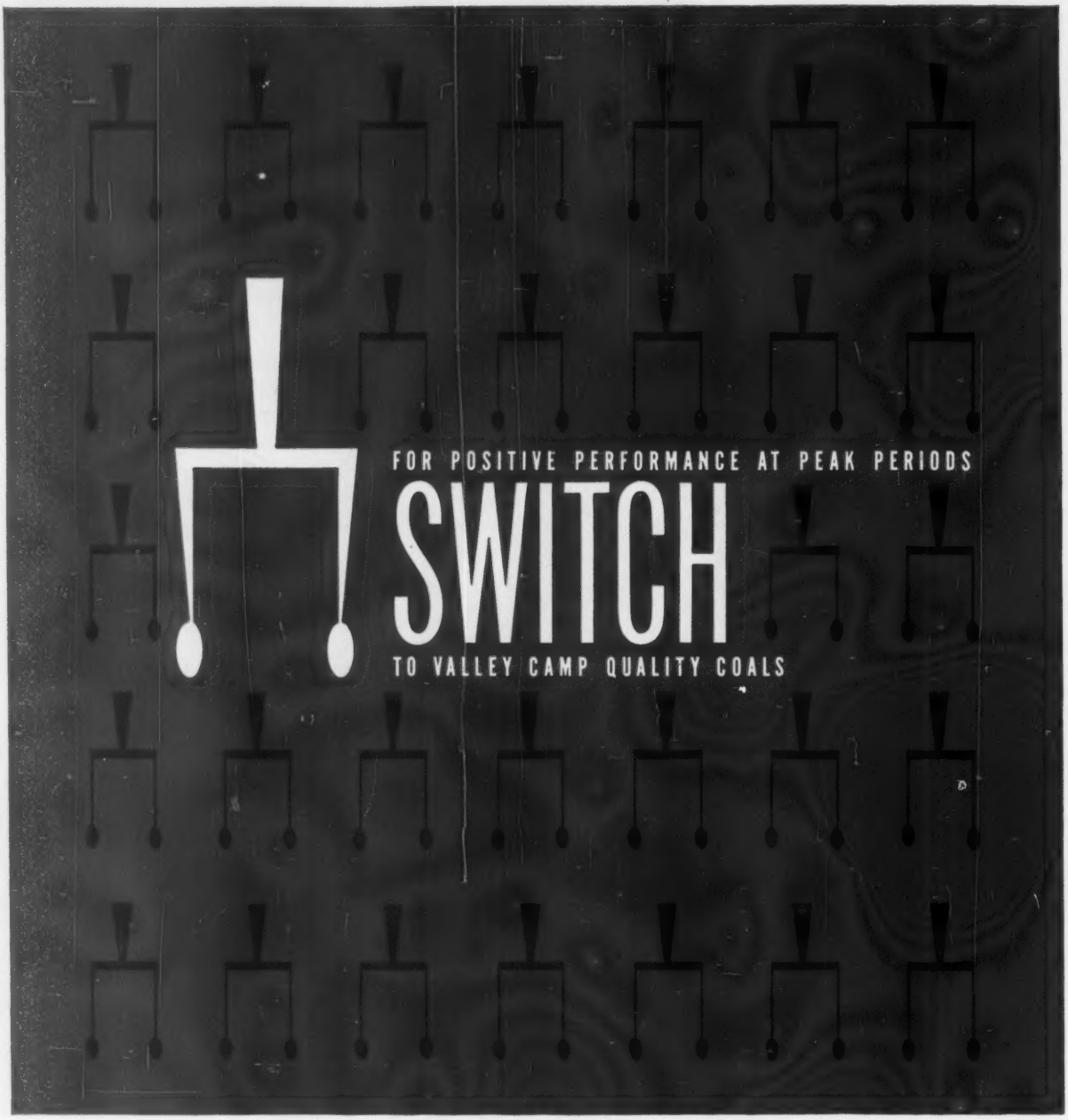
With each B&G "OC" Exchanger, a Manufacturer's Data Report for Unfired Pressure Vessels, Form No. U-1, as required by the A.S.M.E. Code rules, is furnished. This form is signed by a qualified inspector, holding a National Board Commission, certifying that the construction conforms to the latest A.S.M.E. Code for unfired pressure vessels. The A.S.M.E. "U" symbol is stamped on each exchanger.

These exchangers are custom-designed units, built to your specifications. Inquiries are invited.

BELL & GOSSETT
COMPANY
Dept. GX-36, Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto 16, Ontario

For more facts circle 245 on Reader Service card, p 117



Valley Camp Quality Coals respond to peak power surges in a positive way. This superior performance is the result of exacting control in every step of their preparation.

Impurities in the raw coal are removed by thorough washing. Moisture is controlled by the most efficient thermal drying processes. Sizes and consist are carefully determined before shipment. The 'finished product' provides an outstanding burning performance.

Our combustion engineering service is available to analyze your problems, to help you get peak performance with Valley Camp Quality Coals.

THE VALLEY CAMP COAL COMPANY

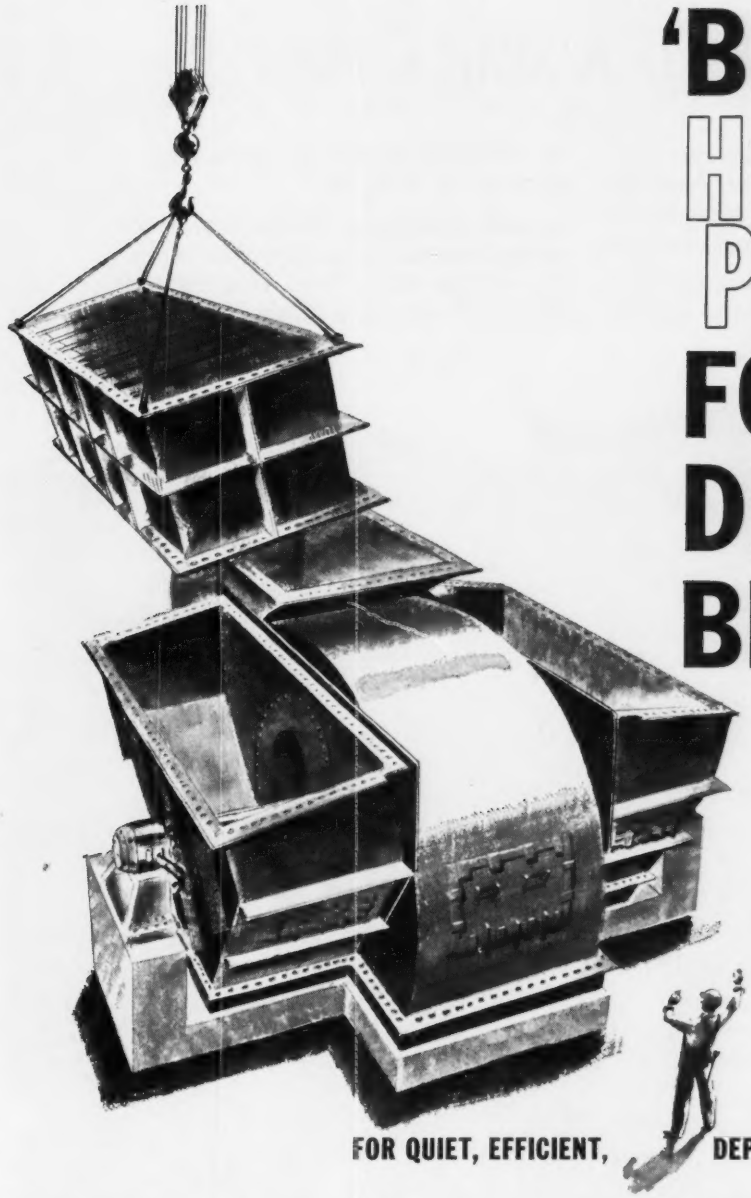
Western Reserve Building • Cleveland 13, Ohio

SUBSIDIARIES —
Great Lakes Coal & Dock Co., Milwaukee, Wis. • Great Lakes Coal & Dock Co., St. Paul, Minn. • Fort William Coal Dock Co., Ltd., Fort William, Ont. • The Valley Camp Coal Co. of Canada Ltd., Toronto, Ont. • Kelley's Creek & Northwestern Railroad Co. • Kelley's Creek Barge Line Inc. • Pennsylvania & West Virginia Supply Corp.

SALES OFFICES —
Philadelphia • Baltimore • Buffalo • Pittsburgh • Wheeling • Cleveland • St. Paul • Cincinnati • New York • Milwaukee • Superior, Wis. • Fort William, Ont. • Toronto, Ont.

For more facts circle 246 on Reader Service card, p 117

'BUFFALO' HIGH PRESSURE FORCED DRAFT BLOWERS



FOR QUIET, EFFICIENT, DEPENDABLE SERVICE

'Buffalo' blowers are "tailor made" to move greater volumes of air at higher static pressures (to 80 inches WG and beyond) and lower brake horsepower without excessive noise.

Buffalo makes over seventeen different types of draft fans in more than fourteen sizes and in all possible arrangements. Each has a smoothly contoured housing designed to provide a uniform flow of air from inlet rotor to ductwork. Depending on operating conditions, either the air foil or backward curved blade design will be specified.

Sound and vibration are dampened by the solid construction of both housing and inlet boxes to assure longer-lasting, vibration-free service. And, where required, additional attenuation may be engineered into the system.

You'll find our engineering representatives, located in cities throughout the country, qualified to assist you in selecting and operating the proper blower for your job.

AIR HANDLING DIVISION

BUFFALO FORGE COMPANY

Buffalo, New York

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

'Buffalo' Air Handling Equipment to move, heat, cool, dehumidify and clean air and other gases.

'Buffalo' Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.

'Buffalo' Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.

Squier Machinery to process sugar cane, coffee and rice. Special processing machinery for chemicals.

POWELL MAKES IT A SIMPLE MATTER

To find the right valve for power plant installation, just call Powell. It's that simple, since Powell can supply just about any type of valve you may need to control water, oil, gas, air, steam or corrosive fluids.

What's more, you don't have to wonder about Powell performance. It's built-in through sound engineering, development, materials and workmanship . . . and proved day in, day out.

So, remember, finding the right valve can be a simple matter when you specify Powell. For further information, call your nearby Powell Valve Distributor (there's one in every major city), or write us direct.

2500-pound Steel Pressure Seal Gate Valve—Fig. 125023. Mounted with electric motor operator for remote control.

1500-pound Steel Pressure Seal Horizontal Lift Check Valve—Fig. 11365. Special design provides maximum flow when wide open.

900-pound Steel Pressure Seal Angle Valve—Fig. 19033. Powell Pressure Seal Valves are available for pressures from 600 pounds through 2500 pounds and higher.

See our catalog in Sweet's

115th year of manufacturing industrial valves for the free world

POWELL HIGH PRESSURE VALVES

THE WM. POWELL COMPANY CINCINNATI 22, OHIO

For more facts circle 248 on Reader Service card, p 117

LOUIS N ROWLEY, EDITOR • DECEMBER 1961 • ESTABLISHED 1882 **Power**

Toward engineering unity

Those who regard the need for unity of the profession as one of the paramount problems facing engineers could not help but be heartened by the recent news of a projected consolidation of the two largest societies. The boards of directors of the American Institute of Electrical Engineers, with some 70,000 members in the U.S. and Canada, and the Institute of Radio Engineers, with a worldwide membership of 91,000, have endorsed the concept of a merger, and have appointed a committee to determine its feasibility and form.

The endorsing resolution points out that "advancement of the theory and practice of electrical and radio engineering and the educational and scientific objectives of both institutes may be better served by . . . one organization in which all present members would be included and in which they would enjoy the same rights and privileges now conferred on them by their separate organizations."

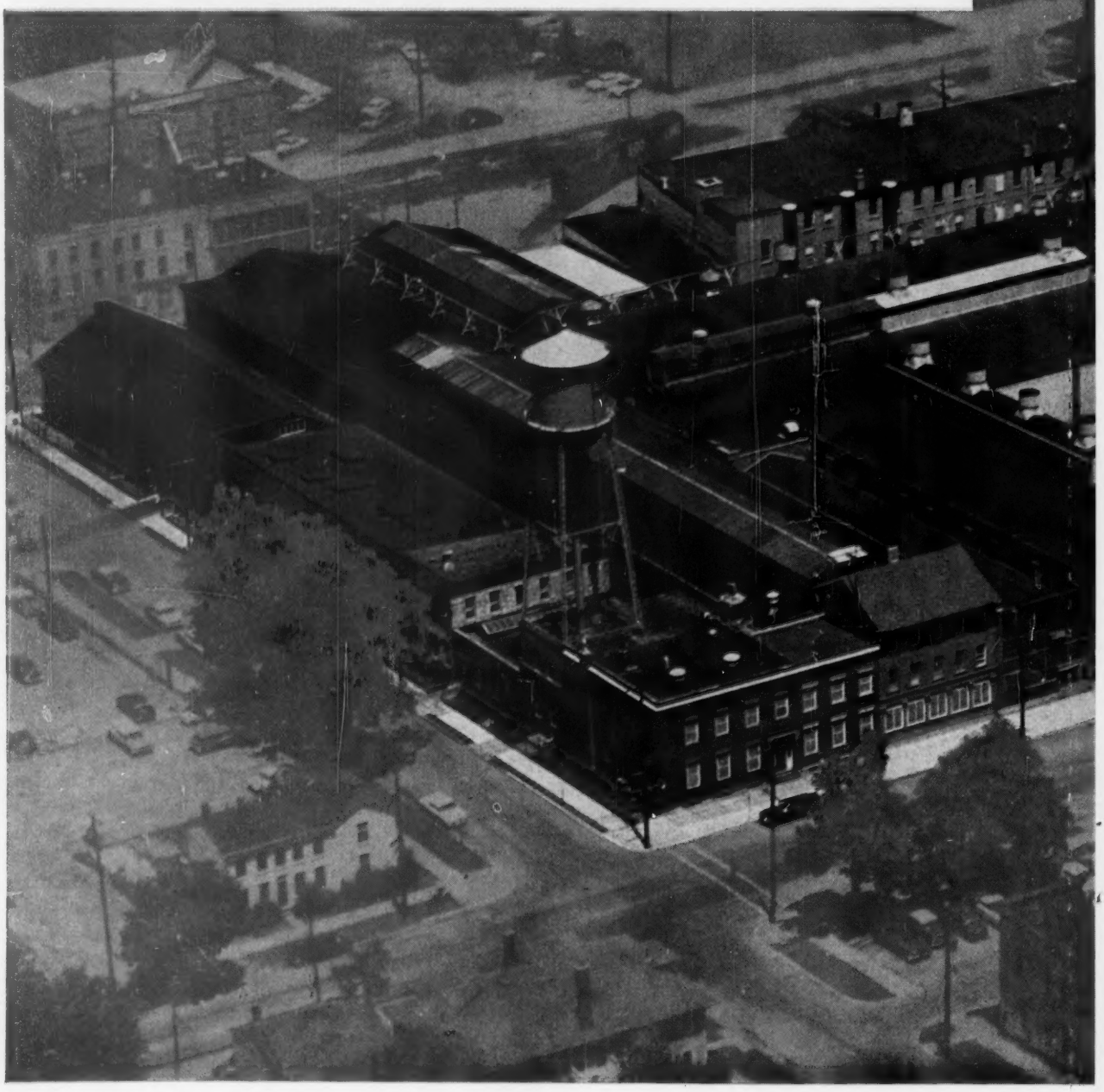
Regardless of the final form to be taken by the consolidation, some clear gains should be realized. Duplicated efforts in committee activities will almost surely be eliminated and a reduction in the number of technical meetings and conferences should also result. Consolidation of the administrative activities of the two societies, if that is contemplated, should either reduce operational costs or permit a higher degree of member service at the same cost. Finally, the more than 150,000 engineers in this greater technical area will be able to act in unison on matters of common concern instead of speaking with two separate and sometimes conflicting voices.

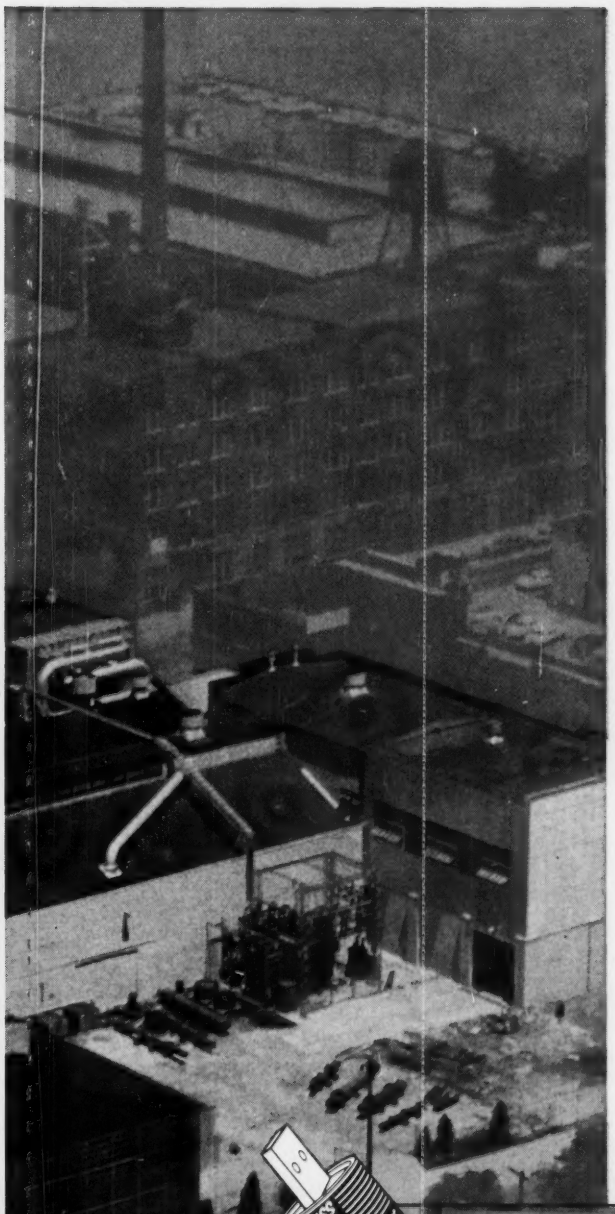
In view of the gains this program should yield, it is to be expected that the membership of the two societies will act favorably when the completed plan is put before them. And it is not unlikely that this merger might start the ball rolling in some other areas where technical-society activities duplicate at least partially and where the best interests of individual members and the profession would be served by consolidation.

For many years now, the goal of unity in the engineering profession has been sought through various plans of confederation or joint action by the several major societies. In the most recent upsurge of such activity, AIEE has played a leading role. It is to be hoped that the great new international society resulting from the projected merger will put its even greater weight behind this movement. If we can continue to merge societies in closely related technical fields, and can fit the resulting fewer and stronger societies into a coordinating structure, we will be in a fair way to have a unified profession that can speak for engineers with a single voice.

Electrical Protection goes MODERN with BUSS Fuses . . .

at Sandusky Foundry & Machine Co.
Sandusky, Ohio





THIS ALL FUSE INSTALLATION PROVIDES NEEDED HIGH INTERRUPTING CAPACITY—AND SAVED AN ESTIMATED $20,000

A new electrical system was installed at the Sandusky Foundry and Machine Co., to feed a 1000 KVA annealing furnace and plant feeders and sub-feeders.

The engineers at Universal Marine Construction Co., Sandusky, Ohio who designed and installed the job, estimated the available fault current would be in the neighborhood of 75,000 amperes.

To be sure of obtaining the needed safe and dependable protection BUSS Hi-Cap and FUSETRON dual-element fuses were installed.

DEPENDABLE PROTECTION AT A $20,000 SAVING

Including the cost of fuses and switches, an estimated $20,000 was saved over what it would have cost to use mechanically operated devices with an interrupting rating of only 75,000 amperes.

This BUSS and FUSETRON fuse installation also permitted the electrical system to be co-ordinated, so outages on feeder and sub-feeder circuits can be limited to the circuit on which trouble occurs.

ELECTRICAL SYSTEM NOT DISTURBED WHEN TRANSFORMER CAPACITY WAS INCREASED

Shortly after the original installation, additional transformer capacity was added,—bringing the available fault current to approximately 150,000 amperes.

No change in the main service panels was needed, however, as the 200,000 amp. interrupting capacity of BUSS Hi-Cap fuses is still adequate to assure safe protection.

Neither was a change required in the protection of feeder circuits because FUSETRON fuses have adequate interrupting capacity to safely handle any fault that might occur on them.

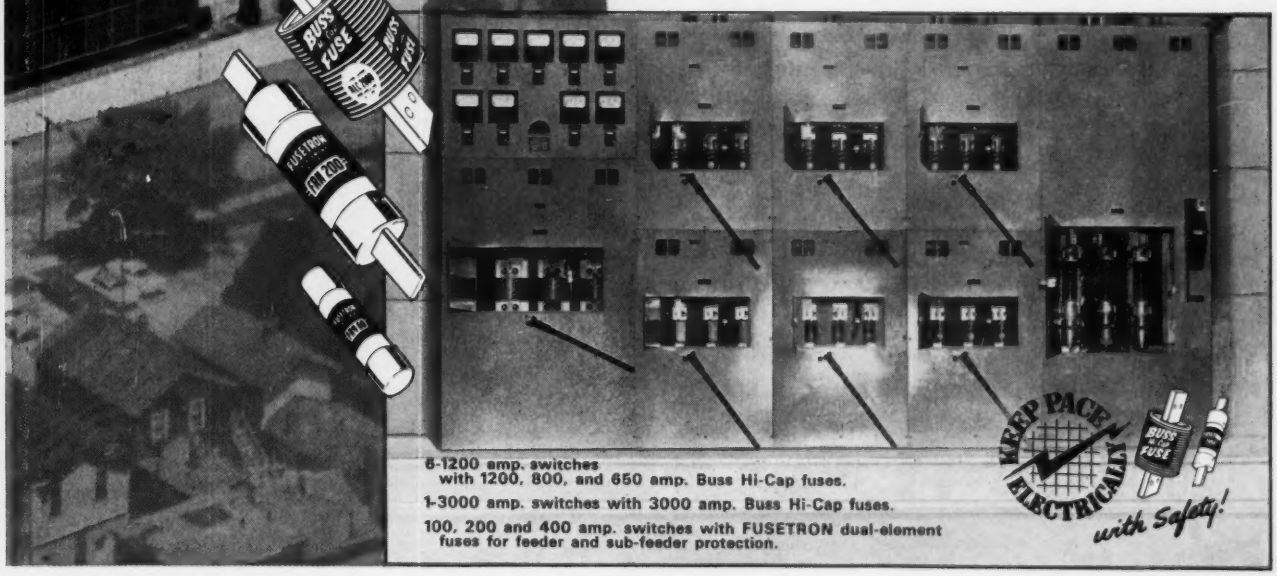
SAFE PROTECTION REMAINS SAFE

After years of inactivity, BUSS Hi-Cap and FUSETRON fuses provide the same safe, accurate protection if called upon to open as they would on the day installed. Dust, fumes, corrosion or age cannot increase the capacity of fuses or lengthen their blowing time.

For more information on how to select the proper fuse, write for the new BUSS booklet . . . *Basic Protection for Electrical Power Systems.*

BUSSMANN MFG. DIVISION, *McGraw-Edison Co.,* **ST. LOUIS 7, MO.**

1161

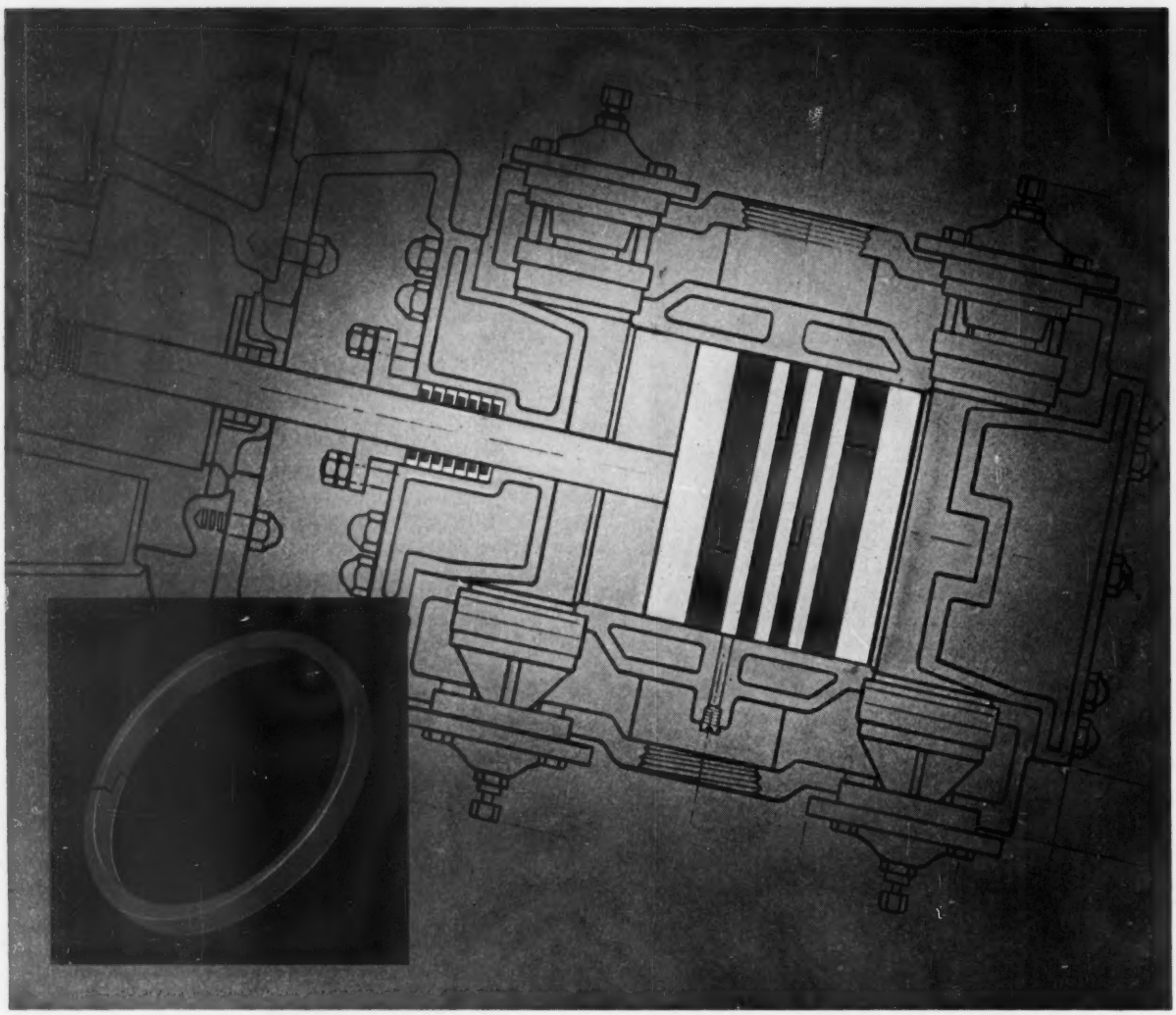


6-1200 amp. switches with 1200, 800, and 650 amp. Buss Hi-Cap fuses.

1-3000 amp. switches with 3000 amp. Buss Hi-Cap fuses.

100, 200 and 400 amp. switches with FUSETRON dual-element fuses for feeder and sub-feeder protection.

For more facts circle 249 on Reader Service card, p 117



How piston rings of TEFLON® saved $1,600 per year in compressor maintenance alone

In a plant manufacturing chemical intermediates, a two-stage compressor handled ethyl chloride. In this service, standard carbon piston rings required constant lubrication and maintenance during their average life of 2,000 hours. Conversion of this unit to piston rings of a TEFLON TFE resin had dramatic results. These rings operated for 10,000 hours without maintenance. Lubrication and product contamination were eliminated. On this one compressor, the plant saved $1,600 in maintenance costs alone.

Piston rings of TEFLON are your most logical and economical choice whenever reduced lubrication would be desirable . . . whenever problems of oil contamination arise . . . whenever ring brittleness causes handling, installation or operating difficulties. If you are buying a new compressor, specify rings and packings of a TEFLON TFE resin. To convert your present equipment, check with your compressor manufacturer or qualified ring supplier for engineering and design assistance. For further information, write: E. I. du Pont de Nemours & Co. (Inc.), Dept. P-12, Room 2526, Wilmington 98, Del.

In Canada: Du Pont of Canada Limited, Box 660, Montreal, Quebec.

DU PONT REG. U.S. PAT. OFF.

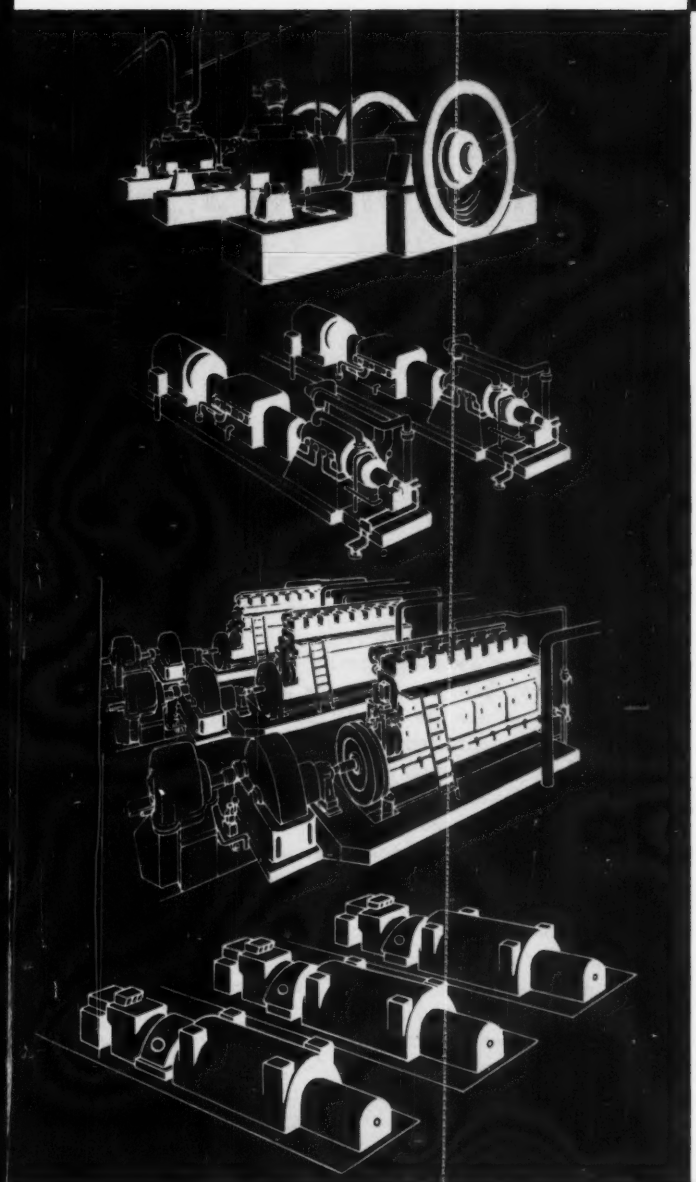
TEFLON®
FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

By B G A SKROTZKI, Associate Editor

Energy system economics...



getting the most energy for the fewest dollars

How are your dollars best spent to meet your growing energy demands? There's a wide variety of equipment and hookups available today, and you want to select the best for your system, whether it be central refrigeration, steam supply, fluid handling, compressed gas, chilled water or electric power.

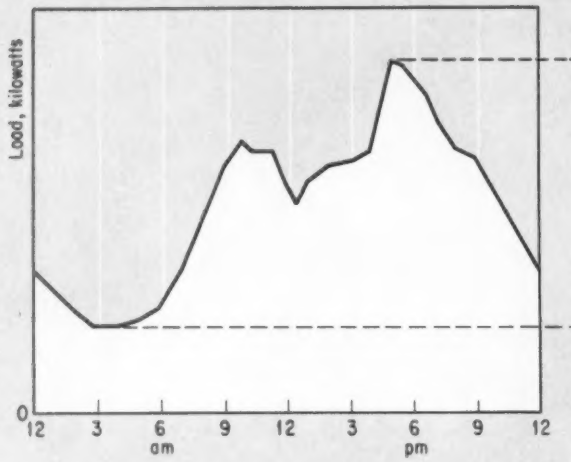
With all investment and operating-cost data in hand, how do you go about choosing the best system? Here you must apply principles of engineering economics to the special problems of energy supply.

The energy systems handle media of radically different character, but for financial operating comparisons they are evaluated by essentially the same methods. We've picked electric power generation to illustrate the practical use of energy-system economics. These 24 pages show how to evaluate electric energy systems, but you can translate these methods to other energy-carrying systems by substituting lb per hr, cfm, Btu per hr, gpm or any measure used in other systems for kw and kwhr. Your aim: find the arrangement that promises lowest total annual cost of operation and capital charges. This will be one of the important factors in making the final choice of system layout.

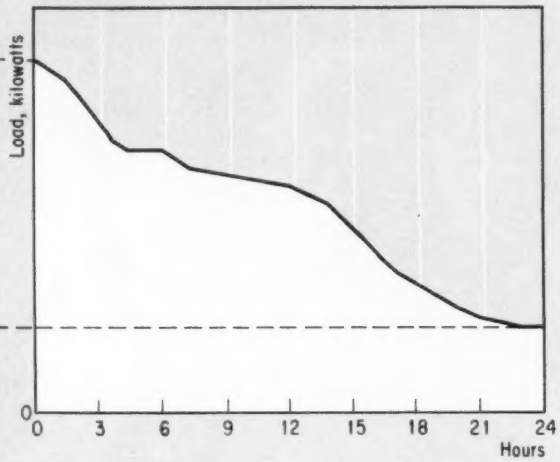
Once your energy system is built, do you run it for best economy? To do this you must know your incremental costs. "Doing it by ear" on the basis of average performance curves only wastes fuel or energy if you don't know the actual cost of every energy unit. Here POWER shows the importance of the incremental rate in scheduling your equipment operation for best overall plant performance.

a **Power** special report • December 1961

Chronological and duration curves define energy-system loads



1 Chronological daily-load curve shows total kilowatt demand on a system at every moment of a day. Area measures kwhr



2 Load-duration curve is simply a rearrangement of daily-load curve with loads set up in descending order of magnitude

First look at today's and tomorrow's load and energy demands

To design a plant for maximum economy we must know the nature of the load it will have to carry. Easiest way to describe this load is by graphs—either chronological or duration curves, Fig. 1 and 2.

Chronological daily load curve, Fig. 1, shows total load at every moment of the day. Since the curve plots kw vs time in hr, area under the curve measures product, kw $\times$ hr $=$ kwhr of energy for the day.

This curve holds information important to plant operators. It lets them know what loads to expect on given types of days, so they can prepare the engines or units to take on load at given hours, be ready to take off engines when load drops to maintain system economy.

Load-duration curve, Fig. 2, is simply a rearrangement of the chronological curve of Fig. 1. To get it, we cut the daily load curve into many vertical strips and then arrange them in descending order. Here, too, area under the curve measures kwhr of energy for the period.

The load-duration curve offers the advantage of summarizing loads for a day, week, month or year. This is a great help in plant design: in one simple curve a whole year can be summarized, showing peak demand, all variations in demand down to the minimum, length of time they existed and total energy involved.

Curve factors help measure the load and its relation to the plant. Fig. 3 shows a typical load-duration curve for one year in the life of a typical city or regional system. Line above the curve gives installed capacity of the power plant serving this load.

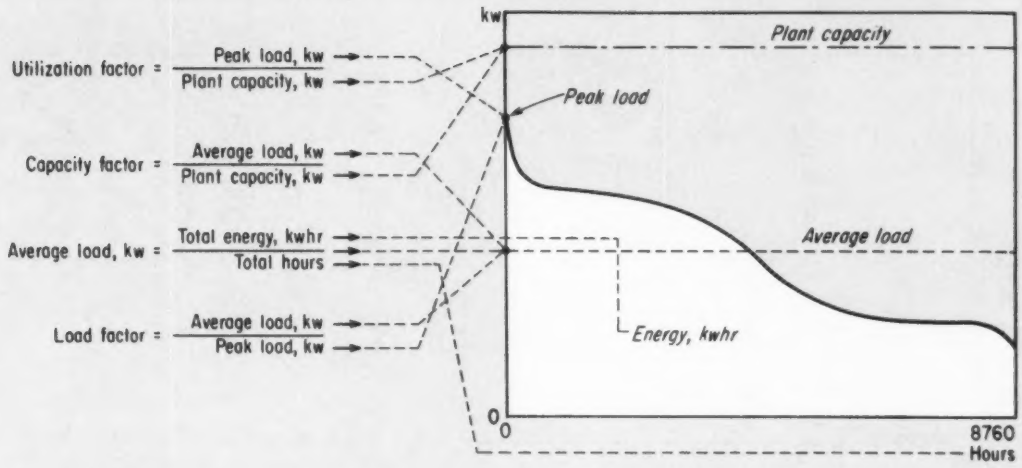
Utilization factor shows the extent to which the plant capacity is used to meet the peak demand. As this approaches 1.0 it may signal the need for additional capacity. On the other hand, in some interconnected systems the plant utilization factors may rise to 1.1 and even 1.2, meaning that the plant carries 10 or 20% more than its rated nameplate capacity. In other words, plant's capability is higher than its rating because of the conservative design of its components. Most plants, in fact, have capabilities exceeding their ratings. But it's wise to check with the equipment builders on advisability of using this built-in reserve as regular operating capacity.

Capacity factor shows how near the plant runs to its full rating. When there are several plants on a system, the most efficient usually runs close to 1.0; least efficient acts as a peaking plant and may barely top zero. Notice the difference between *capacity* factor and *load* factor—the two are often confused needlessly.

Average load is easy to understand; it's the average height of the load curve. If the plant ran continuously at the average load, it would generate the same amount of energy that the actual load curve shows.

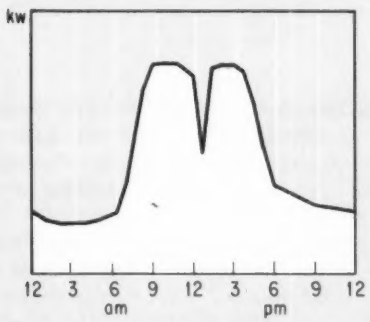
Load factor measures variability of the load-duration curve. As it approaches 1.0 the curve is nearly rectangular, but at 0.5 it can take myriad shapes. For instance, it could be at peak load for half the total time, or it could be at half peak load all the time with the exception of one short sharp peak lasting only one hour in the whole year. More often it's a tapering curve as in Fig. 3, with variable loads during the year.

Component loads. Most all municipal, regional and industrial loads are made up of components; their sum at any given moment creates the total demand. It's unlikely

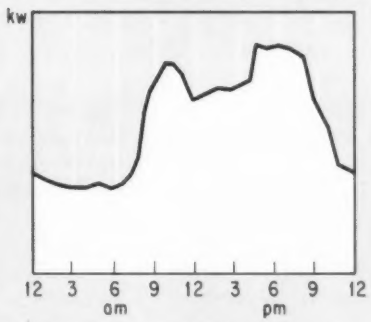

Utilization factor = Peak load, kw / Plant capacity, kw
Capacity factor = Average load, kw / Plant capacity, kw
Average load, kw = Total energy, kwhr / Total hours
Load factor = Average load, kw / Peak load, kw
kw
Plant capacity
Peak load
Average load
Energy, kwhr
0
0
8760
Hours

3 Annual load-duration curve variations and how they relate to the capacity of the generating plant can be measured by a variety of ratios or factors. This type of information must be available to the designer if he is to plan an efficient overall energy system

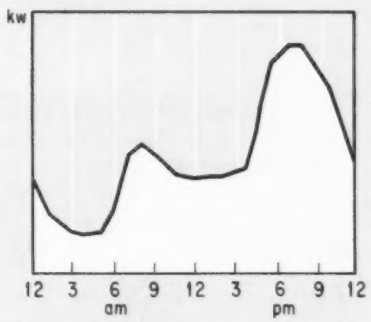
Total system demands are combined from many separate elements



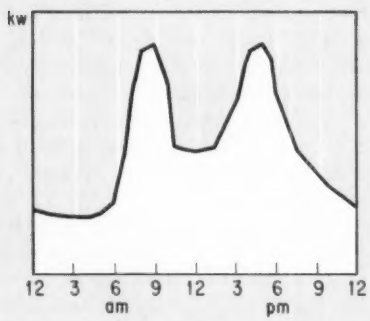
4 Groups of industrial plants running for one shift have high loads during the day



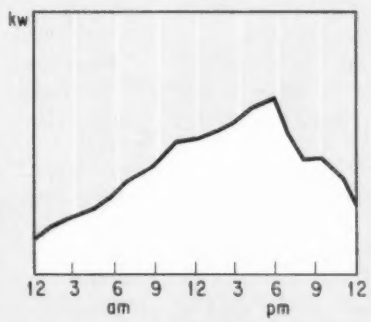
5 Commercial loads of shops, offices, hotels persist into late evening on weekdays



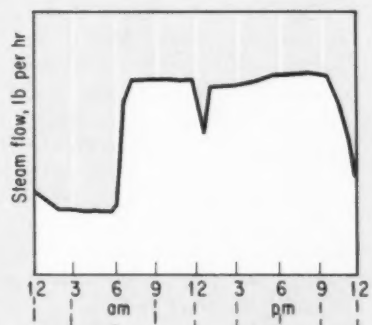
6 Residential loads feature broad evening peak demands on every day of the week

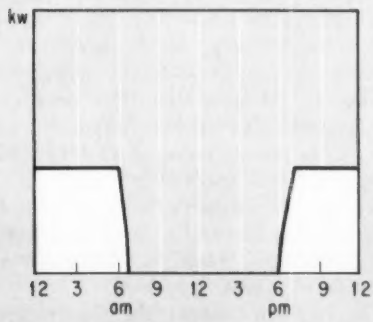


7 Urban electric roads have two sharp peak loads on every working weekday

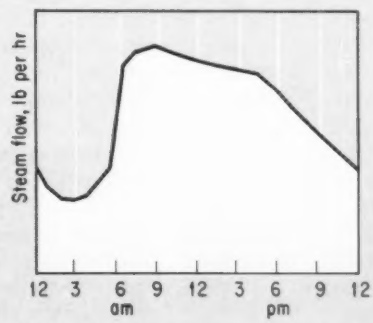


8 Water-pumping load varies with season. Here it rises to peak in the late pm

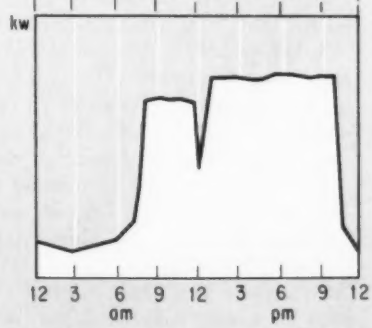




9 Street lighting features steady load during darkness. It's all off during day

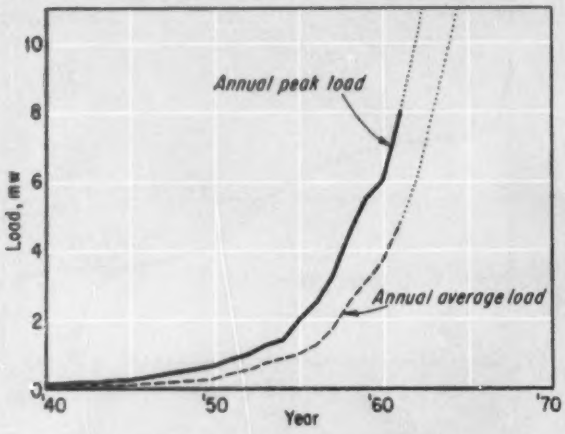


10 District-steam supply on winter weekday has sharp morning rise for heating

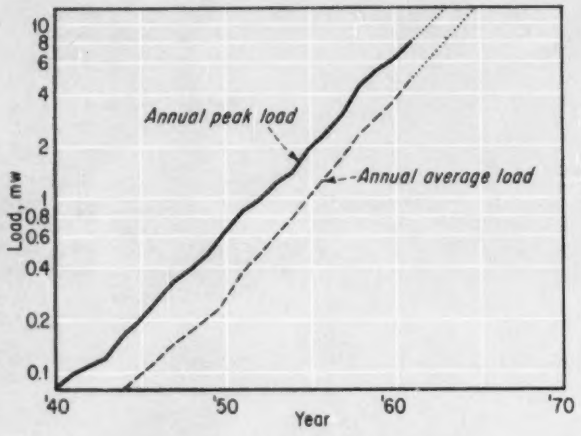


11 Industrial plants with coincidental steam and electric loads run cheaply

Past growth of energy system hints at its future growth pattern



12 Historical variation of peak and average system loads gives clue to future loads you can expect and new capacity needed



13 Extrapolation of load trends often can be made easier by plotting the kw on a semi-logarithmic chart (see Fig. 12)

that component demands will peak at the same time. This diversity of peak demand helps make central-station generation an economical energy system.

Fig. 4 to 9 show the character of typical daily-load curves for various load groups. With the exception of street lighting, most of them sink to the minimum level during early morning hours. Each individual curve varies with the type of day, weather and season. The percentage distribution of these load types on a central-station system determines shape of the system load curve as in Fig. 1, 2 and 3. Diversity usually flattens the load curve.

Fig. 10 is a typical winter-day load curve for a district-steam system. Most of the steam is used for space and hot-water heating; a small part may go to electric-generator and other drives. Sometimes the steam is supplied by backpressure turbines or automatic-extraction turbines on the central-station electric system, instead of directly from boilers. This economical arrangement contributes to keeping down overall operating cost.

Fig. 11 shows steam-demand and electricity-demand curves for a private industry that needs both steam and electric energy. These could be typical of a plant running on a 2-shift basis. If there is reasonable coincidence of steam and electric demands, backpressure or automatic-extraction turbines generate the electric energy with great economy. If there is little coincidence, electric energy may be purchased from the local utility system.

Load growth is the common worldwide experience of energy-supply systems. This raises another problem: expanding power-plant capacity to meet the growing peak demand. To do this effectively we must know at what rate the peak load is expanding year by year.

This can be found by plotting the yearly peak load on a graph, as in Fig. 12, for as far back as data is available. But often we come up with a sharply rising curve when plotting the data on arithmetical coordinates. Such a curve is difficult to project with any confidence, even for a short span like a year or two.

Our job is usually easier if we plot the same data on semi-logarithmic coordinates, Fig. 13. If the data still does not suggest a straight-line trend, at least it will produce a much flatter curve, easier to extrapolate for several years into the future.

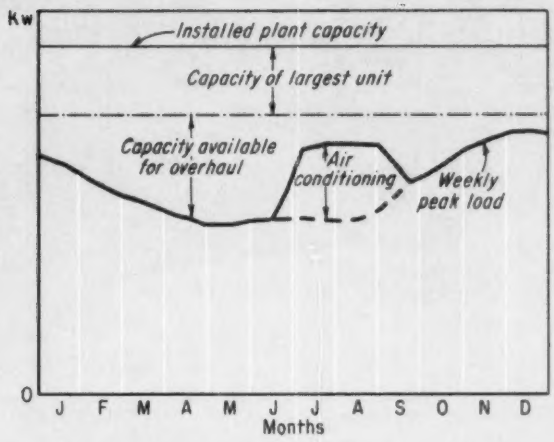
To get the complete story, it's best to plot yearly average loads on the same curve. This gives an idea of where the load factor is trending over the years. If the peak-load and average-load curves tend to approach each other the load factor is rising, and vice versa. Fig. 13 suggests a rising load factor—the national experience. Projection of straight-line growth shown by the dotted lines in Fig. 13 was plotted on the arithmetic coordinates of Fig. 12.

Peak-load studies ought to be supplemented by data on the trends of separate components as in Fig. 4 to 9. Important changes in these individual demands, that could have a vital effect on power-plant planning a few years later, may be masked for several years in the total load trend for the entire energy system.

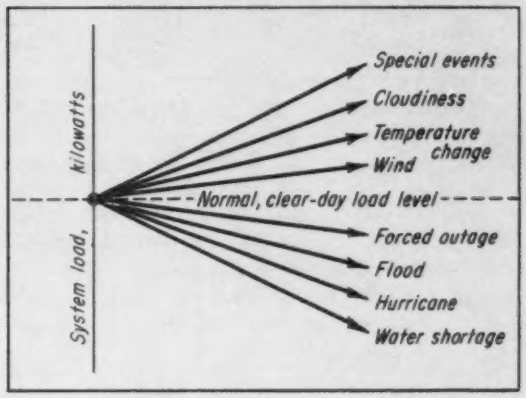
For most systems a plot of the weekly peak loads throughout a year may show a trend like the one in Fig. 14. Historically, peaks arose in early winter at the time of shortest daylight. But in the past decade, availability of room air conditioners for summer cooling has changed the traditionally low peaks of the summer season; in some systems the yearly peak now appears in the summer! So if you suspect that this or some other type of energy-using equipment is experiencing rapid growth, try to measure this growth and project its future magnitude—avoid a major planning headache later. This situation is also important in private industrial energy systems; here, too, keeping tabs on the energy needs of all departments will put you in a position to supply power to grow.

Whatever type of energy system you're responsible for, it's wise to keep analyzing all parts of it to make sure it can handle present and future demands. This means adequate instrumentation conscientiously used.

To return to Fig. 14 for a moment, the trend to grow-



14 Weekly peak loads vary through the year. Many annual peaks rise in winter, but air conditioning may make summer peaks



15 Variety of conditions may change the load from its usual level, either up or down. Some causes affect plant planning

ing summer loads brings up another problem in plant planning: creation of double peaks in one year. Systems with many generating units are hard-pressed to find a time to take them out of service for periodic inspection and overhaul. Sometimes this has meant installing extra capacity to allow adequate overhauling time for all units on the system. Moral: keep on top of your system needs to assure smooth service for the future.

Load variations are always possible if there's a basic change in the need for a particular service. But energy demand can be influenced by other factors that have a system-wide effect. The designer must prepare for them in his equipment, but more important, system operators must be aware that these influences exist.

Fig. 15 illustrates factors that can cause the total system load to rise or fall. Industrial-power systems might be affected by similar situations. Operators should be alert so they can make adequate preparations.

Some special event like an important political broadcast or a football game may bring many TV and radio receivers into operation that normally would be idle. This raises a municipal system load above normal, but it seldom, if ever, happens just at the time of the system's annual peak load.

Cloudy weather or the passing of a thunderstorm darkens building interiors, so electric lights are turned on when they would normally not be used. On systems having summertime peaks this demand might coincide with the annual peak, so extra capacity may be needed to meet the situation. Normal annual wintertime peaks usually result from early darkness coinciding with existing high industrial loads.

Atmospheric temperature changes profoundly influence electric loads. A temperature drop may cause electric heaters to be turned on, or electric motors that drive burners for steam and hot-air heaters. A temperature rise flips the switch on air conditioners and fans, with the important system peak-load effects we've just talked about.

Wind has a noticeable effect. It raises the cooling rate of buildings and so creates demand for more heating energy. In some climatic conditions the wind can be more important than atmospheric temperature change.

Hurricanes drop the load in two basic ways. They may (1) knock out part of the distribution system or some consuming equipment or (2) put generating units out of service because of flooding or other damage. Usually a few days' worth of repairs restore the system to normal, except if damage has been severe.

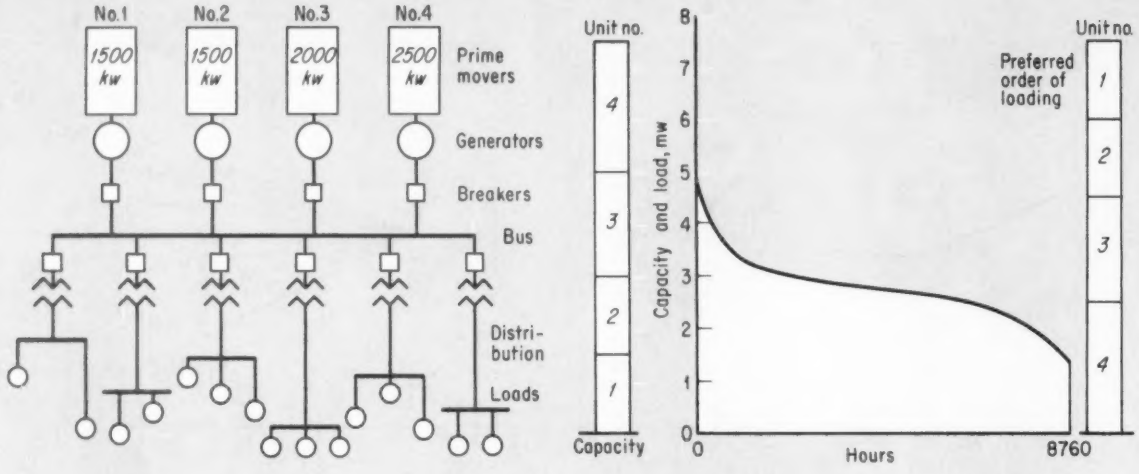
Floods may act like hurricanes in end result, but with less-widespread damage. If the plant is on a waterfront, however, it may be knocked out of service for extended periods by record floods not predicted when the plant was originally designed.

Forced outage of a major generating unit because some vital part fails may force you to dump part of the load, if reserve capacity is not available at the crucial time. Systems that serve secondary loads are able to do this without danger of customer repercussions.

When reserve capacity has been reduced to zero by forced outages, the system load can sometimes be cut by lowering the voltage at electric-generator terminals. Sometimes voltage has been cut by as much as 5% to achieve a 5% reduction in load. Filament lamps will shine less brightly and some motor drives may have trouble as current flows rise to the breaker-tripping level. Extreme reductions should be tried cautiously—only as a last resort to keep a system running.

Momentary load fluctuations may be a problem for some energy systems. Curves of Fig. 4 to 11 suggest smooth changes in demand, and they hold true where the load is lighting or motors driving fans. At the other extreme we have spot-welding operations, motors driving stamping machines, urban traction systems with vehicles drawing frequent high starting currents. Such loads take wide and erratic swings and need special treatment of generator governing systems.

Reliability of the system must be balanced against investment



1 Power plant has variety of unit capacities; growing loads encourage installing larger units to expand capacity. Installed capacity often protects you against losing largest unit at time of peak. Preferred loading order uses the newest unit most often

How much plant capacity to protect the load?

A power plant must be sized to carry the largest load you expect. Plant may be designed to handle load described by the annual-load-duration curve, Fig. 1. Here the largest-capacity unit, 2.5 mw, can be lost and the load still carried at time of peak. This is called a *1-unit reserve*. To establish service continuity, plant size must be increased substantially above the peak load.

Plant capacity can be established on one of several premises, table 1. Capacity must at least equal the expected peak load, and this can be called the *minimum need*, item 1. This might be adopted where the load is intermittent and there is enough time at no load to take units out for overhaul and inspection. In addition, losing load at times should not cause serious financial loss.

When continuity of service is needed, we must understand that no mechanical equipment is absolutely reliable to the extent that it will *always* be available at *any time* it's wanted. All types of prime movers are forced out of service about 1 to 3% of their running time. So for *minimum protection* the plant's capacity should equal peak load plus capacity of the largest unit.

For very small plants we might use the principle of *maximum protection* and supply two units, each capable of carrying the peak load by itself. This criterion may be too costly for large plants because of the high capital investment involved in doubling the capacity.

When we have a load-duration curve with a load factor near 1.0 we might adopt a policy of *conservative protection*. Here the capacity equals peak load, plus capacity of the largest unit, plus some additional capacity so units can come out for overhaul. We may have to take some capacity out of service at peak time; in effect, this often means that installed capacity equals load plus capacity of the two largest units in the plant.

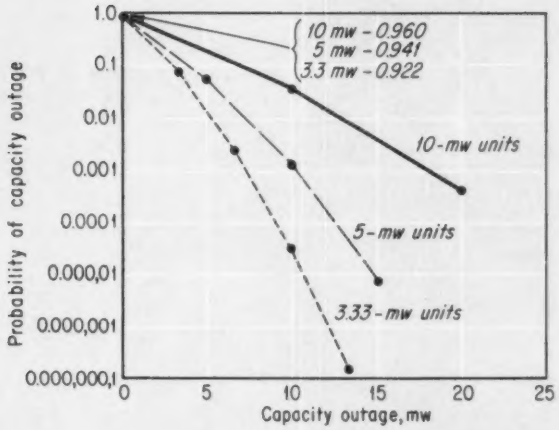
As mentioned before, most plants have an inherent reserve for *emergency protection*. This is the amount of load reduction possible through lowering the generator voltage—load is cut about proportionally to voltage.

Outage probabilities. While we have talked about protecting the load to preserve service continuity, we must realize that such protection is not absolute. As long as equipment is subject to failure we must live with the chance that at some time all units in a plant will be forced out of service simultaneously to completely shut down the energy system. As actual experience shows, this may happen at *any* time.

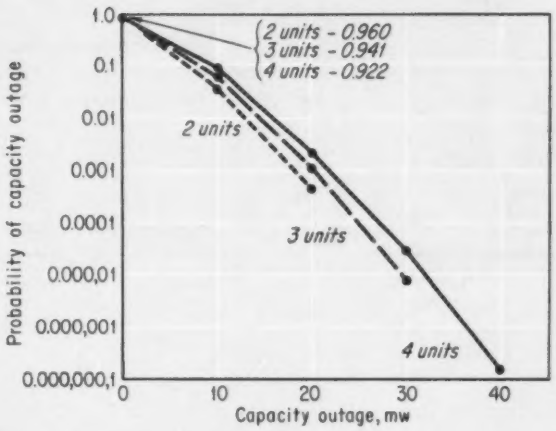
We must decide on what is a reasonable amount to invest in spare capacity. This boils down to a willingness to spend so much money to reduce probability of outages to a given level; for this we use the:

Probability theory. Here we must know what the likely availability of the units will be, based on performance of existing units like those we will install.

Usual practice surveys the operating records to establish probability of in-service time P and probability of out-of-service time or forced outage Q, as defined in table 2. Note that these definitions account only for hours of *forced* outage, not hours of idle time or hours of scheduled-overhaul outage. Probabilities are figured on the basis of exposure to active service or generation time. Presumably a unit standing idle will not be wearing out and so it won't be subject to forced outage.



2 This study compares 2-, 3- and 4-unit plants to supply load with 10-mw peak and maintain a 1-unit reserve over the peak



3 As equal-sized units are added to a growing plant, probability of given-sized outage increases to erode 1-unit protection

These probabilities are figured on an annual basis. Since they vary in magnitude from year to year, an average of several years gives us our answer.

Simple arithmetic then shows that for any one unit $P + Q = 1.0$. We can combine several units, as we do in table 2, and show that the product still equals 1.0.

When we multiply out the factors of the equation we get all the quantities listed in table 2. The various products mean the probabilities of happenings as listed in the table. For instance, if $P_1 = P_2 = P_3 = 0.9$, then $P_1P_2P_3 = 0.729$. This means that on the average—over a long period of time—all three units will be in service simultaneously 0.729 part of the time. In other words, the three units will be in service at the same time 0.729×8760 hr $= 6386$ hr per year *on the average.*

Going by this assumption, $Q_1 = Q_2 = Q_3 = 0.1$ or $Q_1Q_2Q_3 = 0.001$; over a long period of time, all three units will be out of service simultaneously 0.001 part of the time, or the plant will be completely shut down $0.001 \times 8760 = 8.8$ hr per year *on the average.* This will not happen every year; it may happen 16.7 hr every two years, 26.4 hr every three years, etc. As long as units do fail, at some time all will be out of service to completely shut down an energy system. We can only reduce outage probabilities by supplying enough units to minimize shutdown risk.

Unit capacity affects outage probabilities. Let's study three plants: two 10-mw units; three 5-mw units and four 3.333-mw units to supply a load with 10-mw peak. Each has a 1-unit reserve. All units have a forced-outage rate of $Q = 0.02$, see table 3.

The table shows that the probability of having a given capacity available is the same as the probability of having a corresponding capacity outage. Fig. 2 plots the capacity outage vs the probability of that outage. This shows that for any one plant the outage probability decreases as the outage capacity grows. In other words,

1—How much plant capacity?

1 *Minimum need*	Total capacity = peak load
2 *Minimum protection*	Total capacity = peak load + capacity of largest unit
3 *Maximum protection*	Total capacity = 2 × peak load
4 *Conservative protection*	Total capacity = peak load + capacity of largest unit + capacity for overhaul outage
5 *Emergency protection*	At times of reserve capacity loss, load may be shaved by dropping system voltage to cut it to capability of available units in active service

2—Probabilities of outages

$$P = \frac{\text{Hours in operation}}{\text{Hours in operation + hours forced out of service}}$$

$$Q = \frac{\text{Hours forced out of service}}{\text{Hours in operation + hours forced out of service}}$$

$P + Q = 1$

$(P_1 + Q_1)(P_2 + Q_2)(P_3 + Q_3) = 1$

$P_1P_2P_3$ = probability of three units in service

$P_1P_2Q_3$ = probability of units 1 and 2 in service, unit 3 out

$P_1P_3Q_2$ = probability of units 1 and 3 in service, unit 2 out

$P_2P_3Q_1$ = probability of units 2 and 3 in service, unit 1 out

$P_1Q_2Q_3$ = probability of unit 1 in service, units 2 and 3 out

$P_2Q_1Q_3$ = probability of unit 2 in service, units 1 and 3 out

$P_3Q_1Q_2$ = probability of unit 3 in service, units 1 and 2 out

$Q_1Q_2Q_3$ = probability of three units out of service

If all three units have same P's and Q's, then expansion of equation $(P + Q)^3 = 1$ means:

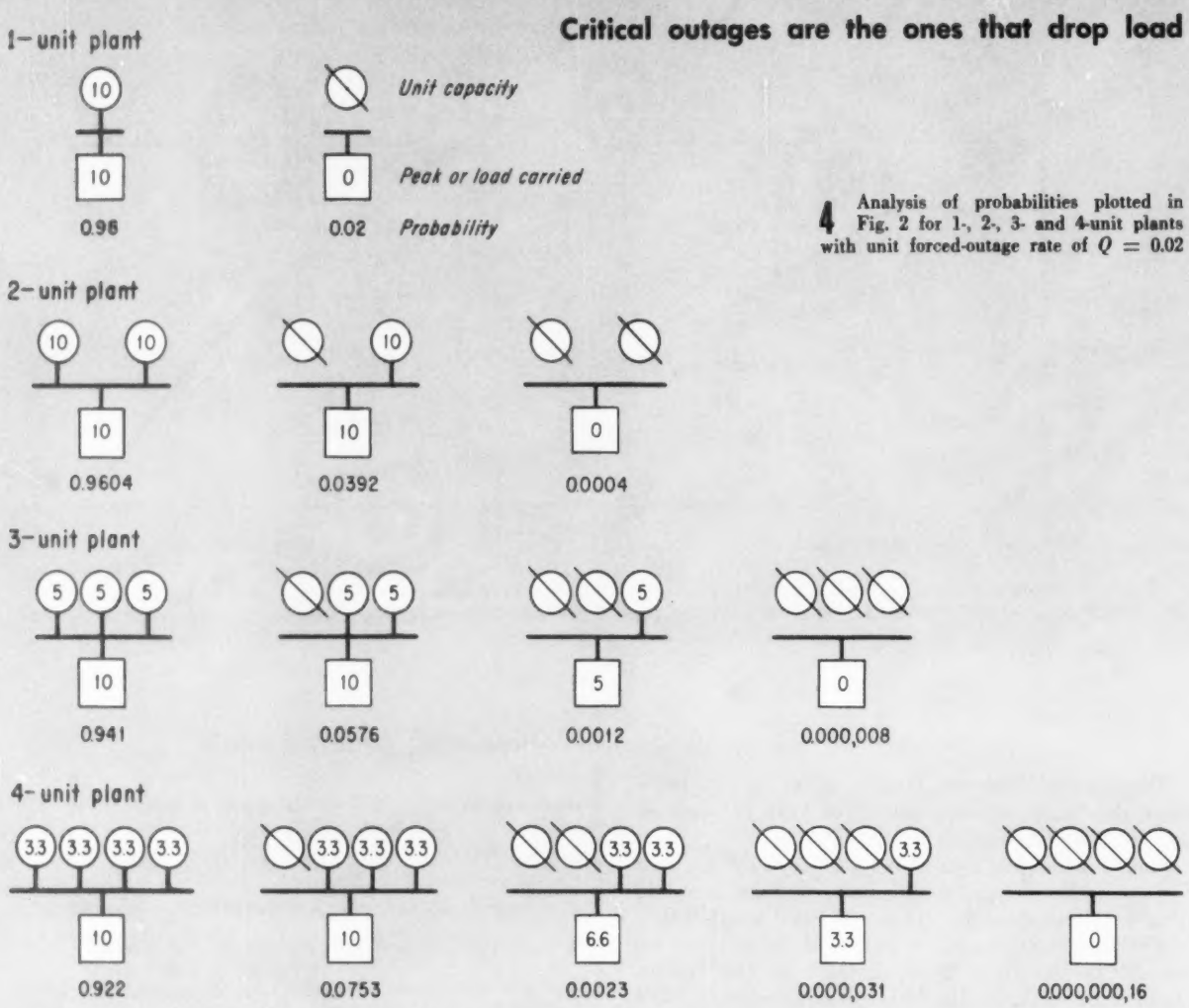
P^3 = probability of three units in service

$3P^2Q$ = probability of two units in service and one out

$3PQ^2$ = probability of one unit in service and two out

Q^3 = probability of all three units out of service

Critical outages are the ones that drop load



4 Analysis of probabilities plotted in Fig. 2 for 1-, 2-, 3- and 4-unit plants with unit forced-outage rate of $Q = 0.02$

large outages happen very seldom, small outages more frequently.

But what does this table tell us about the relative attractiveness of the three plants from an outage-probability standpoint? Losing more than one unit in each plant forces the dropping of load. Let us assume our load has a 1.0 load factor and find the probability of losing capacity in excess of the load, Fig. 4.

If we had a 1-unit 10-mw plant we would lose the entire plant 0.2 part of the time ($Q = 0.02$). Then the relative load loss for this plant would be 10 mw $\times$ 0.02 $=$ 0.2 mw.

The two-10-mw-unit plant must lose both units to drop any load; losing only one unit has no effect. Table 3 shows that probability of losing both units is 0.0004, giving a relative load loss of 10 $\times$ 0.0004 $=$ 0.004 mw.

The three-5-mw-unit plant drops load when losing two or three units:

Outage, mw	*Probability*	*Load loss, mw*	*Relative load loss, mw*
10	0.001,176	5	0.005,880
15	0.000,008	10	0.000,080
	0.001,184		0.005,960

The four-3.333-mw-unit plant must lose two or more units to drop load:

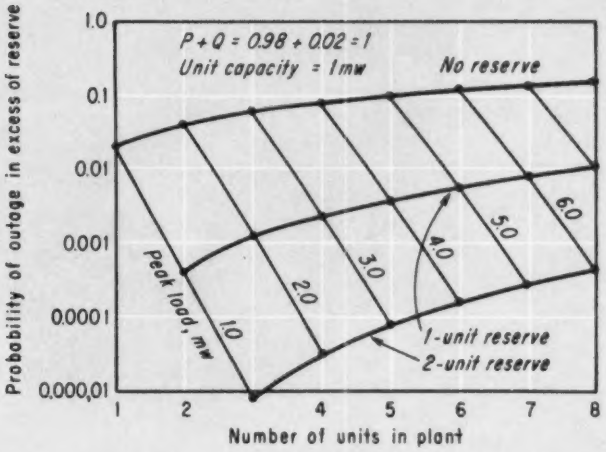
Outage, mw	*Probability*	*Load loss, mw*	*Relative load loss, mw*
6.66	0.002,304,96	3.33	0.007,68
10.00	0.000,031,36	6.66	0.000,209
13.33	0.000,000,16	10.00	0.000,002
	0.002,336,48		0.007,891

Summarizing this data for a load with a 10-mw peak:

Units per plant	*Probability of load loss*	*Relative load loss*	*Plant capacity, mw*
1	0.02	0.2	10
2	0.000,4	0.004	20
3	0.001,184	0.005,96	15
4	0.002,336,48	0.007,891	13.33

The 1-unit plant shows largest relative load loss, but lowest capacity and so lowest investment.

The 2-unit plant has double the capacity but much greater reliability. Here we double the investment to achieve improved continuity. The 3-unit plant would have about 75% of the investment of the 2-unit plant, but it suffers by a 50% larger relative load loss.



5 When a given reserve policy is followed in adding units to plant, probability of outage increases with number of units

The 4-unit plant would have about 66% of the investment of the 2-unit one, but almost doubles relative loss.

This comparison shows that as we attempt to cut investment but still maintain a measure of reliability in the form of a 1-unit reserve, we inevitably raise the probability of outage. We must make up our minds: at what point does the value of load loss exceed the saving we make in plant investment? We could express this in terms of probability of load loss or of outage.

Probability of 0.0004, for example, is the same as $8760 \times 0.0004 = 3.5$-hr outage per year. A probability of 0.0023 is $8760 \times 0.0023 = 20.2$-hr outage per year. From experience, we may decide that more than an average of 15 hr of outage per yr is intolerable. This becomes our standard. When the outage probability exceeds 15 hr we must install more than one reserve unit. Of the four plants above we would favor the 3-unit 15-mw plant since its outage probability is $8760 \times 0.0012 = 10.5$ hr per year on the average.

Adding units to a growing plant also leads us to change our reserve policy in respect to the number of reserve units. Fig. 3 shows the change in outage probabilities of a plant starting with two 10-mw units and adding equal-sized units as its peak load grows (assuming all units have a forced-outage rate of $Q = 0.02$). As the plant grows, probability of all units being available at the same time decreases and outage probability goes up.

A 1-unit reserve policy, followed as the plant expands, gives us outage probability in excess of reserve capacity which grows as listed in table 4, right.

Fig. 5 charts the trends for plants built with 1-mw units, following no-reserve, 1-unit and 2-unit reserve policies. This shows clearly that as the number of units increases the outage probabilities also go up.

Outage at peak time. Outages can happen at any time; those at times of minimum plant load do not cause as large a total relative load loss as we calculated. The critical time, of course, is the peak load. If it comes 100 hr a year the probability of the peak is $100/8760 = 0.0114$ part of the total operating time in a year.

Assume probability of an outage in excess of reserve of 0.0012. The probability of an outage at peak time will be $0.0114 \times 0.0012 = 0.000,014$ or about one day in 200 yr. This is a measure of the coincidence of peak outage with peak load, but it still does not alter the basic probability of having an equipment outage of $8760 \times 0.0012 = 10.5$ hr per yr.

3—Study of supplying 1-unit protection for a 10-mw peak load with two, three and four equal-sized generating units

Probability of in-service and outage for all units:
$P + Q = 0.98 + 0.02 = 1.00$

1. Plant with two 10-mw units:

$(P + Q)^2 = 1.0$

Quantity	Capacity available, mw	Capacity outage, mw	Probability
P^2	20	0	0.9604
$2PQ$	10	10	0.0392
Q^2	0	20	0.0004
			1.0000

2. Plant with three 5-mw units

$(P + Q)^3 = 1.0$

P^3	15	0	0.941,192
$3P^2Q$	10	5	0.057,624
$3PQ^2$	5	10	0.001,176
Q^3	0	15	0.000,008
			1.000,000

3. Plant with four 3.33-mw units

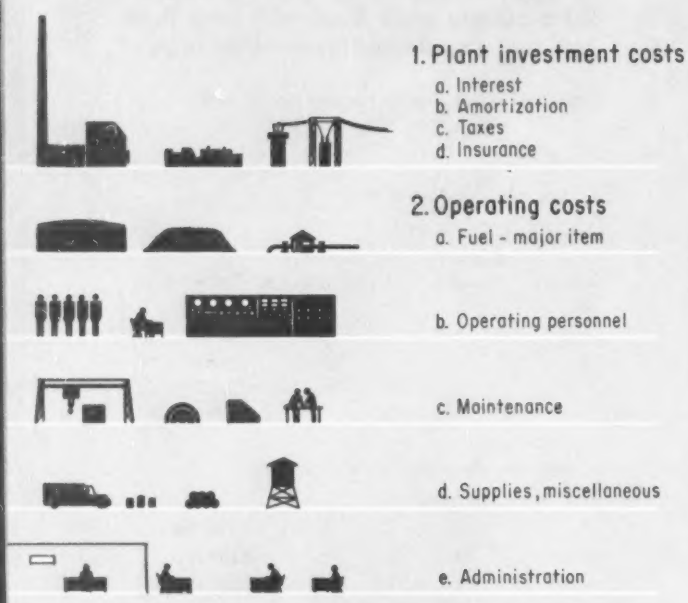
$(P + Q)^4 = 1.0$

P^4	13.33	0	0.922,368,16
$4P^3Q$	10.00	3.33	0.075,295,36
$6P^2Q^2$	6.66	6.66	0.002,304,96
$4PQ^3$	3.33	10.00	0.000,031,36
Q^4	0	13.33	0.000,000,16
			1.000,000,00

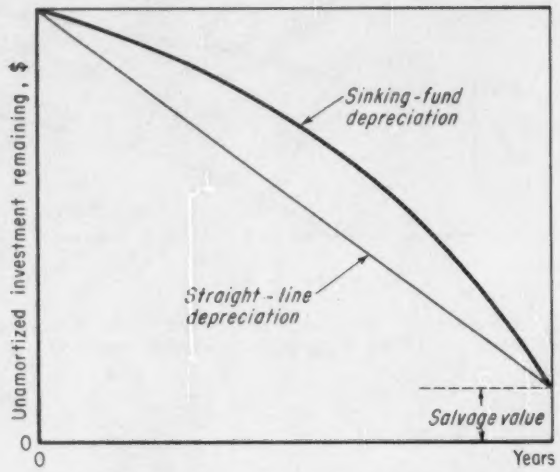
4—Outage probability changes with growth

Number of units	Protected peak, mw	Probability of outage in excess of reserve
2	10	0.000,40
3	20	0.001,18
4	30	0.002,34
5	40	0.003,84
6	50	0.005,69
7	60	0.007,86
8	70	0.010,34

Operating costs and capital charges make up total you pay for energy



1 Cost of energy generated includes capital charges on equipment and a variety of operating costs, fuel being the biggest



2 Capital may be recovered by straight-line depreciation or by a sinking-fund accumulation—you can use either of the two

What will energy output cost?

Total price we pay for energy from power plants consists of: (1) capital charges (2) operating costs. Capital charges depend on plant investment, operating costs on the running of the plant day-by-day.

Capital costs, Fig. 1, include: (1) depreciation (2) interest (3) taxes and (4) insurance. The initial investment breeds charges that have to be met annually.

Depreciation recognizes that machines wear out or are superseded by newer designs. To maintain a profitable business in energy generation, the revenues you receive must include a component to recover the initial investment. Rate at which capital is recovered depends on estimated life of the machines, financing arrangements made to repay the investment and the method of amortization. These all vary with the type of ownership—private industrial, privately owned public utility or governmental utility—and type of industry.

When capital is raised by serially maturing bonds, an equal number may be retired each year, as table 1 shows. Here the $1-million issue has a 20-yr life and the bonds pay an effective interest rate of 6%. Each year $50,000 worth of bonds are retired and 6% interest is paid on the remaining outstanding bonds. This arrangement is analogous to straight-line depreciation. For the 20-year life, total interest of $630,000 has been paid. The equivalent annual interest on the investment is then considerably less than 6%: $630,000/20 = $31,500 or 3.15%.

When financing and equipment-life terms are about the same, annual depreciation charge for table 1 would be $50,000/$1,000,000 = 0.05 or 5%. Coupling depreciation with the equivalent interest rate: 3.15 + 5.00 = 8.15%.

For financing continuing businesses, the sinking-fund method is often used, table 2. Constant total annual payments cover both repayment of capital and interest charges. Total payments here are higher than in table 1 because capital is repaid more slowly at first. Equivalent annual interest rate works out to: $743,665/20 = $37,183 or 3.72%. Total of depreciation plus interest rate is 3.72 + 5.00 = 8.72%.

Fig. 2 shows an estimated salvage value that can be used to repay capital. Here we see the difference in unamortized capital during the life of a loan or machine for the two methods of depreciation allowance. Some designers assume the salvage value of a machine only pays for its removal, so depreciation covers full investment.

Interest rate used in evaluating a new plant depends on financing methods. For many businesses this will be a mixture of bonds and stocks. Average rate used must cover the needs of all the sources of capital.

Where all financing is by bonds, an item should be added to include objective earnings expected from the energy system. This may be called interest or profit. At any rate it should be a part of the total interest.

Insurance guards most energy systems against financial

Schedule of payments . . .

1—For straight-line amortization of loan

End of year	Amount of loan owed	Repayment on loan	Payment of interest	Total year-end payment
0	$1,000,000	———	———	———
1	1,000,000	$50,000	$60,000	$110,000
2	950,000	50,000	57,000	107,000
3	900,000	50,000	54,000	104,000
4	850,000	50,000	51,000	101,000
5	800,000	50,000	48,000	98,000
6	750,000	50,000	45,000	95,000
7	700,000	50,000	42,000	92,000
8	650,000	50,000	39,000	89,000
9	600,000	50,000	36,000	86,000
10	550,000	50,000	33,000	83,000
11	500,000	50,000	30,000	80,000
12	450,000	50,000	27,000	77,000
13	400,000	50,000	24,000	74,000
14	350,000	50,000	21,000	71,000
15	300,000	50,000	18,000	68,000
16	250,000	50,000	15,000	65,000
17	200,000	50,000	12,000	62,000
18	150,000	50,000	9000	59,000
19	100,000	50,000	6000	56,000
20	50,000	50,000	3000	53,000
		$1,000,000	$630,000	$1,630,000

2—For sinking-fund amortization of loan

End of year	Amount of loan owed	Repayment on loan	Payment of interest	Total year-end payment
0	$1,000,000	———	———	———
1	1,000,000	$27,186	$60,000	$87,186
2	972,814	28,817	58,369	87,186
3	943,997	30,546	56,640	87,186
4	913,451	32,379	54,807	87,186
5	881,072	34,322	52,864	87,186
6	846,750	36,381	50,805	87,186
7	810,369	38,564	48,622	87,186
8	771,805	40,878	46,308	87,186
9	730,927	43,330	43,856	87,186
10	687,597	45,930	41,256	87,186
11	641,667	48,686	38,500	87,186
12	592,981	51,607	35,579	87,186
13	541,374	54,704	32,482	87,186
14	486,670	57,986	29,200	87,186
15	428,684	61,465	25,721	87,186
16	367,219	65,153	22,033	87,186
17	302,066	69,062	18,124	87,186
18	233,004	73,206	13,980	87,186
19	159,798	77,599	9587	87,186
20	82,199	82,199	4932	87,131
		$1,000,000	$743,665	$1,743,665

loss from accidents and vandalism. Policies cover fire, explosion, windstorm, hail, flood, public liability, title, machinery and many others. Annual premiums prorated on the value of the property pay for this protection.

Taxes in all forms levied by federal, state, county and municipal governments must be paid for energy systems. The tax base may be value of the property, or revenues, unemployment, income and the like. In usual evaluating practice most of the taxes are related to the investment so calculations can be more easily handled.

Total capital charges. The capital-charge rates used for an energy system vary with the organization owning the system. Some typical rates for power plants:

	Private utility	*Governmental utility*
Interest	6.80%	2.50%
Depreciation	1.10	2.20
Insurance	0.25	0.25
Taxes	5.80	0.00
Total capital charge	13.95%	4.95%

Some governments may add a rate in lieu of taxes of 1.0 or 2.0%.

Operating costs, Fig. 1, include fuel, operating labor, maintenance, supplies and administrative expenses. The important items here vary with generation, while some minor ones stay essentially constant.

Fuel. A thermal plant burns fuel about in proportion to the load. For most plants, fuel is the largest item of annual operating cost, and depends on type of fuel, plant factor, plant thermal efficiency and fuel price.

Operating labor needed to supervise generating plants has been brought close to the minimum by increasing automatic control. Men are still required for fuel and refuse handling, to inspect and control operating machinery and for general plant security. A plant usually needs about the same number of men for any load range except when it is on cold standby.

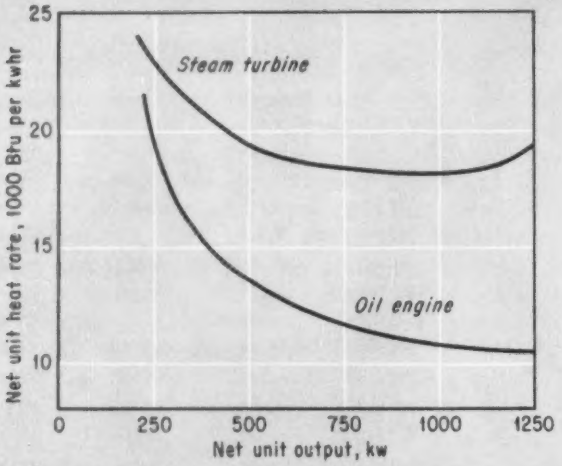
Maintenance. Most plants have their equipment taken out on a regular schedule for inspection and repairs. This helps forestall forced outages, but of course the equipment is unavailable when under repair. For an overall average, equipment appears to be available about 90% of the time. Maintenance costs involve both labor and materials—they generally vary with the plant factor.

Supplies include water, lubricating oils, water-treatment chemicals, tools, office materials, cleaning items, etc. This account is often a catchall for items not charged to any of the other categories. It is usually the smallest of the operating costs.

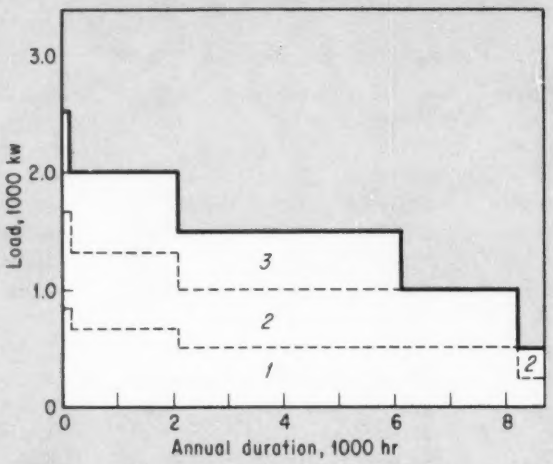
Supervision, for plants of any importance, includes superintendents, chief engineer, chemist and efficiency engineer to insure competent operation of the plant.

Choosing new equipment. Basic principle in choosing new energy equipment strives for minimum overall operating cost consistent with reliability. In the following pages we will look at several situations and learn how equipment should be evaluated in each respect. We will study the factors for choosing a new plant to serve an entirely new load; we will look at factors governing replacement of an obsolete unit; we will examine principles guiding choice of a new unit to be added to a growing system, either for base loading or peaking.

Plant heat-rate curves and load durations fix expected performance



1 Net unit heat rates compare 1250-kw boiler and steam turbine with reciprocating internal-combustion oil-engine plant



2 Expected annual-load-duration curve has 2500-kw peak. It's to be protected against forced outage by 1-unit reserve

Choosing your new power plant

Basic method of deciding between alternate plans for energy supply is to compare annual costs over the life of the system. The plan with the lowest annual costs presumably will be the economic choice. In many practical situations, however, factors other than cost play a decisive role in final selection. This is especially true if cost difference between alternates is small.

The principles we have discussed apply to plants and systems of all sizes. An example will explain these principles and how they vary:

Let us consider a new plant. An organization plans to build an entirely new power plant to run its new facilities. It can define load variation as the load-duration curve in Fig. 2. An annual peak of 2500 kw and total energy of 12,580 mwhr have a load factor of $12{,}580{,}000/8760 \times 2500 = 0.575$ for the year. Designers expect this load curve to last indefinitely into the future. First three columns of table 2 detail the load.

Interruption of service would disrupt operations, so a 1-unit reserve is required to guard the plant against forced outages and mitigate facilities shutdown.

After preliminary study, designers choose a plant of three 1250-kw units. This gives a total plant capacity of 3750 kw to supply a protected peak load of $3750 - 1250 = 2500$ kw. At all times enough capacity will be running on the line to let one unit be lost without interrupting service to the load imposed by the facilities.

Preliminary investigation narrows the choice to either a steam plant or a reciprocating oil-engine plant because coal at 40c per million Btu and diesel oil at 65c per million Btu are available in the area. Fig. 1 shows the overall net heat rate of the two types of units, including all plant auxiliaries, in Btu per kwhr net output.

Table 1 summarizes the capacity requirements. Let's assume a survey has shown that both steam and engine units of this size and type have a forced-outage rate of 1.5%. Item 5 checks the probability of outage in excess of the 1-unit reserve for the 3-unit plant and finds it equal to one day in 4.1 years. This is about on the edge of being acceptable. Item 6 shows outage probability for a 4-unit plant with 2-unit reserve: probability drops to one day in 192 years. But designers decide to defer installing the fourth unit until the actual plant has gathered some operating experience.

Table 2 computes total annual fuel costs for each type of plant. The lower basic fuel cost of the steam turbines offsets their higher heat rate compared to the oil-engine plants. Note that 1-unit reserve policy loads the generating units pretty much below their level of top efficiency.

Table 3 lists factors making up the capital-charge rate. The steam-turbine units are expected to turn in a 30-year operating life, the oil engines 20 years.

Interest charged for this plant is modest compared to many industrial organizations. Many industries use a high return to offset rapid obsolescence. They may compensate for this by assigning a short life to a project and demanding a high depreciation. But we assume that our plant will be functioning for its "natural" life and compute the depreciation rate on a straight-line basis: 1/(number of years of life).

Insurance is a typical 0.25% and taxes of all forms related to investment run 3% of capital. Summing up for both plants, we have a 12.55% capital-charge rate for the steam plant and 14.25% for the shorter-lived oil-engine plant.

A detailed study of all land, improvements, buildings, accessories as well as main equipment shows an investment of $310 per kw capacity for the steam plant and $220 for the oil-engine plant. We are now ready to make our economic comparison of the two generating plants.

1—Steam-turbine and oil-engine plants

1 Three 1250-kw units = 3750-kw plant capacity
2 1-unit reserve capacity needed at all loads
3 Protected peak to be carried = 2500 kw
4 Forced-outage rate for both steam and engine plants, Q = 0.015
5 Outage probability check: $(P+Q)^3 = (0.985 + 0.015)^3 = 1.0$
Probability of all units out, $Q^3 = 0.15^3 =$ 0.000,003
Probability of two units out, $3PQ^2 =$
$3 \times 0.985 \times 0.015^2 =$ 0.000,665
Outage in excess of reserve = 0.000,668
or 1/0.000,668 = 1 in 1500 days, or one day in 4.1 years
6 For a 4-unit plant with 2-unit reserve: $(P + Q)^4 = (0.985 + 0.015)^4$
Probability of all units out, $Q^4 = 0.15^4 =$ 0.000,000,05
Probability of three units out, $4PQ^3 =$
$4 \times 0.985 \times 0.015^3 =$ 0.000,013,30
Outage in excess of reserve = 0.000,013,35
or 1/0.000,013,35 = 1 in 70,000 days or one day in 192 years

2—Load and performance

Load, kw	Hours	Energy, mwhr	No. units on	Unit load, kw	Oil engines Ht rt B/kwhr	Oil engines Input, 10^9B	Steam turbines Ht rt B/kwhr	Steam turbines Input, 10^9B
2500	100	250	3	833	11,300	2.83	18,100	4.53
2000	2000	4000	3	667	12,200	48.80	18,600	74.40
1500	4000	6000	3	500	13,500	81.00	19,200	115.20
1000	2000	2000	2	500	13,500	27.00	19,200	38.40
500	660	330	2	250	19,300	6.37	22,800	7.52
	8760	12,580				166.00		240.05

Oil-engine fuel cost at 65¢/10^6 Btu = $166.0 \times 10^9 \times 0.65/10^6$
= $108,000 per yr
Steam-turbine fuel cost at 40¢/10^6 Btu = $240.05 \times 10^9 \times 0.40/10^6$
= $96,000 per yr

3—Capital charge factors

Item	Steam turbines	Oil engines
Life	30 years	20 years
Interest	0.06	0.06
Depreciation	0.033	0.05
Taxes	0.030	0.030
Insurance	0.0025	0.0025
Capital charge rate	0.1255	0.1425
Investment per kw	$310	$220

4—Economic comparison of steam and engine plant

Plant	Steam turbine		Oil engine	
1 Capital charges	310 × 3750 × 0.1255 =	$145,800	220 × 3750 × 0.1425 =	$117,500
2 Fuel costs	At 40¢/10^6 Btu	96,000	At 65¢/10^6 Btu	108,000
3 Operating and maintenance labor	10 men × $5200 =	52,000	8 men × $5200 =	41,600
4 Maintenance material	At 0.05¢/kwhr	6300	At 0.06¢/kwhr	7600
5 Supervision	2 × $8000 =	16,000	2 × $8000 =	16,000
6 Supplies		4000		4000
7 Total annual costs		$320,100		$294,700
		2.54¢/kwhr		2.34¢/kwhr

5—Basics of economic evaluation

1 Rising capital-charge rates favor lower investment plans
2 Rising fuel costs favor higher-cost more-efficient plants
3 All consistent methods of economic evaluation lead to choosing the same plan, though the answers vary in form
4 Fuel costs should be estimated from loads likely to be carried on units and not on full-load heat rate alone

In table 4, item 1, we figure the annual capital charges for each plant by multiplying unit investment, capacity and capital-charge rate. Here the oil-engine plant shows its principal advantage. Item 2 records the fuel costs figured in table 2; the steam plant is lower. In item 3 the steam plant is estimated to need ten men for operation and maintenance at an annual average wage of $5200. The oil-engine plant needs only eight men, earning the same wage. Future inflation possibility should be considered.

Item 4 figures maintenance material at 0.05c per kwhr for the steam plant and 0.06c for the oil engine. Both plants need the same supervision—a superintendent and chief engineer at an average salary of $8000, item 5. Finally, supplies are figured at $4000 a year for each type of plant.

Summing the costs we find the oil-engine plant lower at $294,700 compared to the $320,100 for the steam plant. Dividing these by the 12,580 mwhr generated each year we get 2.34c per kwhr for the oil-engine energy and 2.54c per kwhr for the steam-plant energy. All other factors being equal, we would choose the oil-engine plant.

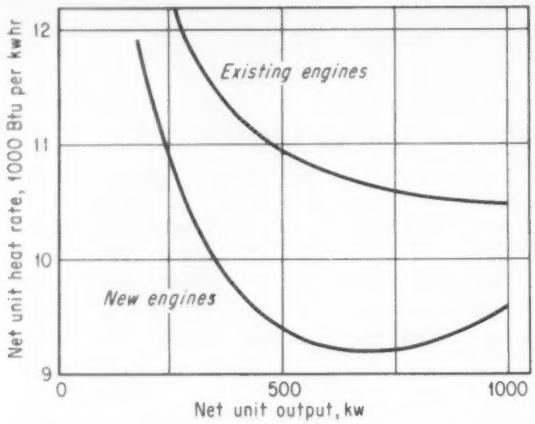
Balancing costs. Let's find the coal cost Y at which the two plants would be equal in annual total costs. This would be a value that reduces steam-plant cost by 320,100 − 294,700 = $25,400. Then $240 \times 10^9 \times Y/10^6 = 96{,}000 - 25{,}400$; solving, Y = 29.4c per million Btu.

As an alternative, what would the steam-unit investment have to be for economic equality? We figure this by equating $Z \times 3750 \times 0.1255 = 145{,}800 - 25{,}400$; solving, we get Z = $263 per kw of capacity. Of course, there are other factors to be carefully considered together with this economic comparison before the final choice is made.

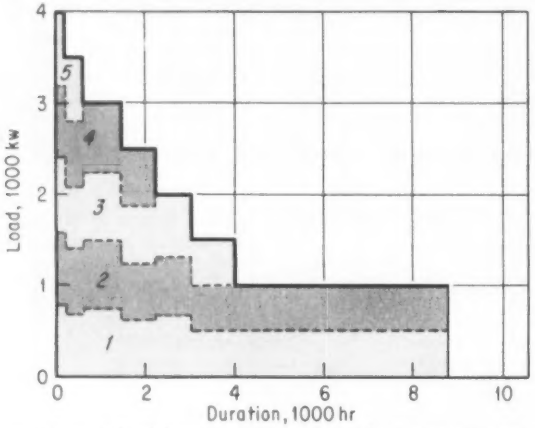
These balancing costs show us how much change is needed in the important operating and investment factors to make the alternate schemes equal. If actual and balancing investments are close, this may spur a critical review of plant design to cut costs.

When fuel costs for alternate schemes using different fuels are close, a painstaking forecast of future fuel-cost trends should be undertaken. Available supplies and probable future demands may inflate prices sharply.

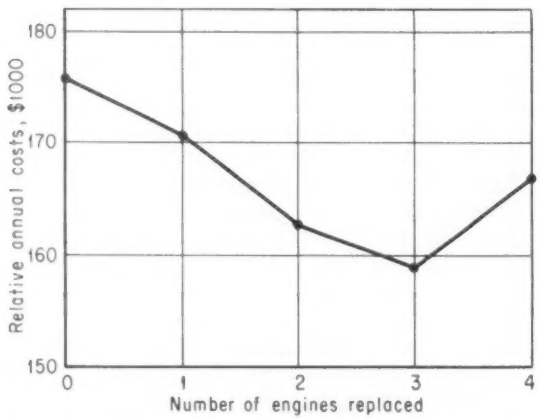
When should old equipment be replaced?



1 These are heat rates of existing engines and new ones proposed to replace some or all of them. Curves include auxiliaries



2 Annual load-duration curve, expected to stay constant into the future, shows division of load—always with a 1-unit reserve



3 Future annual costs will be reduced by replacing as many as three engines with new units. Fourth replacement causes a loss

Advances in the art of energy handling often raise this question: has existing equipment outlived its economic usefulness? Just how to make the comparison often causes confusion, and the stumbling block is what to do about capital charges on the existing equipment which may be replaced. But the answer's simple.

Replacing or keeping the old equipment does not affect commitments for amortizing or financing its investment. In any event capital charges run for the life of the bonds or loan. So the question boils down to whether the *total of capital charges and operating costs* of the new equipment will be less than *operating costs plus taxes and insurance* on the old equipment. When total annual cost of the new equipment comes to less than these specific costs of the old, it's time to make the replacement.

Installing new engines. As an example let's study a power plant with a load-duration curve that stays the same year-to-year, Fig. 2. A unit reserve is always needed on the line, so the plant has five 1-mw units to serve its 4-mw peak demand. Fig. 1 shows the existing units' heat rate. They

3—Combined outputs and inputs for the engines

Total engine inputs in million Btu and outputs in mwhr

Load,	Energy,	5 old units		4 old units and 1 new				3 old and 2 new units				2 old and 3 new units			
				4 old units		1 new unit		3 old units		2 new units		2 old units		3 new units	
kw	mwhr	Input	Output	Input	Output	Input	Output	Input	Output	Input	Output	Input	Output	Input	Output
4000	800	8465	800	6772	640	1480	160	5079	480	2960	320	3386	320	4440	480
3500	1400	14,880	1400	11,904	1120	2582	280	8928	840	5164	560	5952	560	7746	840
3000	2400	25,440	2400	19,080	1800	5538	600	12,720	1200	11,076	1200	6360	600	16,614	1800
2500	2000	21,460	2000	16,095	1500	4615	500	10,740	1000	9230	1000	5365	500	13,845	1500
2000	1600	17,076	1600	11,384	1067	4923	533	5692	534	9846	1067	0	0	14,769	1600
1500	1500	16,380	1500	10,920	1000	4700	500	5460	500	9400	1000	0	0	14,100	1500
1000	4760	51,980	4760	25,990	2380	22,372	2380	0	0	44,744	4760	0	0	44,744	4760
	14,460	155,681	14,460	102,145	9507	46,210	4953	48,619	4554	92,420	9907	21,063	1980	116,258	12,480

1—Obsolescence study factors

1 Five existing units	1000-kw each
2 One-unit installed and spinning reserve	at all loads
3 Investment in old units	$180 per kw
4 Investment in new units	$205 per kw
5 Oil fuel cost for new units	80¢ per million Btu
6 Gas fuel cost for new units	45¢ per million Btu
7 Salvage value of old units if retired now:	$50,000 per unit

2—Load duration and input data

Load, kw	Hours	Energy, mwhr	No. eng	Eng load, kw	Engine heat rates, Btu per kwhr Old	New	Output per eng, mwhr	Input per engine, million Btu Old	New
4000	200	800	5	800	10,580	9250	160	1693	1480
3500	400	1400	5	700	10,630	9220	280	2976	2582
3000	800	2400	4	750	10,600	9230	600	6360	5538
2500	800	2000	4	625	10,730	9230	500	5365	4615
2000	800	1600	3	667	10,660	9220	534	5692	4923
1500	1000	1500	3	500	10,920	9400	500	5460	4700
1000	4760	4760	2	500	10,920	9400	2380	25,990	22,372
	14,460						4954	53,536	46,210
						Annual average heat rate =		10,804	9328

burn oil costing 80c per million Btu.

New engines burning gas at 45c per million Btu are now available; Fig. 1 also shows their heat rate. Installed, they will cost $205 per kw. The old units, which originally cost $180 per kw, can be sold at a net return of $50,000 each. Table 1 summarizes these facts in brief fashion.

How many of the old units should be replaced? First we must figure output and input for the old and new units as they fit into the load-duration curve—all units are alike, which simplifies our problem. Table 2 summarizes load and energy division among the five units—we neglect starting and stopping losses and assume load is always equally divided among the units on the line.

In table 3, with the aid of table 2, we figure inputs and outputs on the old and new engines for various combinations, adding one new unit at a time. We start with the present plant and work up to keeping one old unit and replacing four with new units. Each arrangement must be studied to get a complete answer.

Calculations for each case are shown in table 4. Case A figures pre-

1 old and 4 new units

1 old unit		4 new units	
Input	Output	Input	Output
1693	160	5920	640
2976	280	10,328	1120
0	0	22,152	2400
0	0	18,460	2000
0	0	14,769	1600
0	0	14,100	1500
0	0	44,744	4760
4669	440	130,473	14,020

4—Calculation of comparative annual costs

A—Costs with existing (old) engines

1 Fuel: $155{,}681 \times 0.80 =$ $12,580

2 Maintenance
$14{,}460 \times 0.0012 =$ 17,360

3 Taxes and insurance @ 4%
$\$180 \times 5000 \times 0.04 =$ 36,000

4 Total excluding amortization and interest: $175,940

B—Costs with one engine replaced

1 Correction to 90% availability of new unit: $4953 \times 0.9 = 4458$ mwhr

New-unit input $= \frac{4458}{4953} \times 46{,}210$
$= 41{,}580$ million Btu

Corrected output of old units
$9507 + 4953 - 4458 = 10{,}002$

Corrected input of old units $=$
$\frac{10{,}002}{9507} \times 102{,}145 = 107{,}600$ million Btu

2 Fuel: $107{,}600 \times 0.80 =$ $86,080
$41{,}580 \times 0.45 =$ 18,720

3 Maintenance:
$10{,}000 \times 0.0012 =$ 12,000
$4458 \times 0.0008 =$ 3570

4 Taxes and insurance @ 4%
$\$180 \times 4000 \times 0.04 =$ 28,800
$\$205 \times 1000 \times 0.04 =$ 8200

5 Amortization of new money
$\frac{205{,}000 - 50{,}000}{20} =$ 7750

6 Interest on new money @ 3.5%
$(205{,}000 - 50{,}000)0.035 =$ 5420

7 Total $170,540

8 Saving from replacing one engine
$= 175{,}940 - 170{,}540 = \$5400$ yearly

C—Costs with two engines replaced

1 Correction to 90% availability of two new units: $9907 \times 0.9 = 8916$ mwhr

Input of new units $= \frac{92{,}420}{9907} \times 8916$
$= 83{,}150$ million Btu

Corrected output of old units
$4554 + 9907 - 8916 = 5545$ mwhr

Corrected input of old units
$\frac{5545}{4554} \times 48{,}619 = 59{,}100$ million Btu

2 Fuel: $59{,}100 \times 0.80 =$ $47,280
$83{,}150 \times 0.45 =$ 37,420

3 Maintenance: $5545 \times 0.0012 = 6650$
$8916 \times 0.0008 = 7130$

4 Taxes and insurance @ 4%
$\$180 \times 3000 \times 0.04 =$ 21,600
$\$205 \times 2000 \times 0.04 =$ 16,400

5 Amortization of new money
$\frac{410{,}000 - 100{,}000}{20} =$ 15,500

6 Interest on new money @ 3.5%
$(410{,}000 - 100{,}000)0.035 =$ 10,900

7 Total $162,880

8 Saving from replacing two engines
$175{,}940 - 162{,}880 = 13{,}060$ yearly

D—Costs with three engines replaced

1 No availability correction needed because third new engine can help fill base of load curve when two other new engines are out for overhaul

2 Fuel: $21{,}063 \times 0.80 =$ $16,850
$116{,}258 \times 0.45 =$ 52,300

3 Maintenance: $1980 \times 0.0012 = 2380$
$12{,}480 \times 0.0008 = 9980$

4 Taxes and insurance @ 4%
$\$180 \times 2000 \times 0.04 =$ 14,400
$\$205 \times 3000 \times 0.04 =$ 24,600

5 Amortization of new money
$\frac{605{,}000 - 150{,}000}{20} =$ 22,750

6 Interest on new money @ 3.5%
$(605{,}000 - 150{,}000)0.035 =$ 15,900

7 Total $159,160

8 Saving from replacing three engines
$= 175{,}940 - 159{,}160 = \$16{,}780$ yearly

E—Costs with four engines replaced

1 No availability correction needed

2 Fuel: $4669 \times 0.80 =$ $3740
$130{,}473 \times 0.45 =$ 58,700

3 Maintenance: $440 \times 0.0012 =$ 530
$14{,}020 \times 0.0008 = 11{,}220$

4 Taxes and insurance @ 4%
$\$180 \times 1000 \times 0.04 =$ 7200
$\$205 \times 4000 \times 0.04 =$ 32,800

5 Amortization of new money
$\frac{820{,}000 - 200{,}000}{20} =$ 31,000

6 Interest on new money @ 3.5%
$(820{,}000 - 200{,}000)0.035 =$ 21,700

7 Total $166,890

8 Saving from replacing four engines
$= 175{,}940 - 166{,}890 = \$9050$ yearly

9 Loss from replacing four engines compared to replacing three engines
$= 166{,}890 - 159{,}160 = \$7730$ yearly

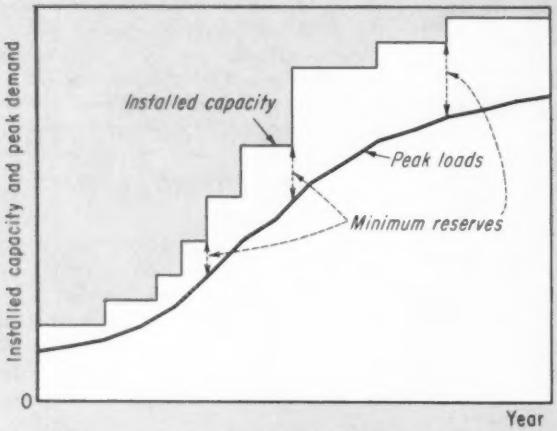
sent plant costs. Maintenance comes to 1.2 mills per kwhr on the present units. Taxes and insurance are ordinarily classed as capital charges, but they should be figured here because they change when the old units are replaced by new. The financing items of amortization and interest won't be affected; they go on for the duration of the bonds and stocks issued to cover them—in other words, they are a constant in all cases and so can be ignored in this comparison of relative annual costs.

In Case B we replace one old engine with a new one. Here we have to adjust for the running of the new engine which we place on base load. Calculation from load duration, Fig. 2 and table 3, assumes that the new unit would run for 8760 hr a year. But experience in this plant shows that units are only 90% available; they are out for overhauls 10% of the time on the average. So we reduce the output and input of the new engine by 10%. The old engines take over when the new unit is unavailable, so their output and input is higher than first calculated.

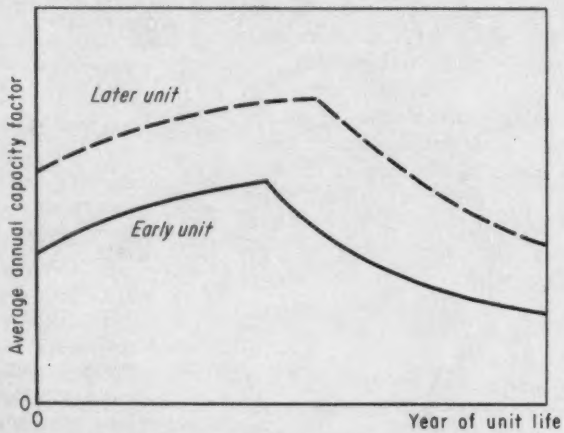
Now we're ready to figure fuel and maintenance costs for both old and new engines. Maintenance on the new engine is expected to be only 0.8 mills per kwhr. Taxes and insurance change because of the difference in investment. We need less new money by the amount of salvage on the old engine. Amortization is on the straight-line basis. Relative annual cost of Case B is $5400 under Case A, so it would pay to replace one engine.

In Case C we replace two old engines. Here again we

Growing energy systems need constant study and special analysis



1 Climbing annual peak loads require periodic expansion of installed capacity. Minimum reserves, too, will probably grow



2 On a growing system, average annual capacity factor of an individual unit rises during early years, then drops off later

How to evaluate growing systems

Up to this point we have studied methods of evaluating loads that stay essentially constant with the years. But the most prevalent condition is growth—the energy system expands yearly at a persistent rate, Fig. 1. To keep the system peak demand protected, blocks of capacity must be added well in advance of the minimum reserve needed.

In choosing among alternative units of capacity we follow essentially the same method we did for the constant load; we look for the unit with the lowest overall annual cost. But we must also take account of future variation in annual output and so annual cost of units working on a growing system. Fig. 3 shows annual load-duration curves for a system starting with three units in the Year 1, with a 1-unit reserve. In the Year 10 peak demand has grown by a factor of 2.5 and in the Year 20 by 4.0, with corresponding growth in kwhr.

Note what happens to the first three units: they finally serve only during peak hours with greatly reduced output. In the Year 20, base-load Unit 6 of the Year 10 is going to be forced off the base when the 11th unit is installed.

These load-duration curves assume the base-load units are available 100% of the time. This is not so—there will be some mitigation of the variation in annual output. The base-load units will produce less than shown, and peaking and intermediate units will produce more when they substitute for the efficient units on the base.

Fig. 2 shows the variation in annual output of two typical units in terms of annual capacity factor. When units serve on the base their outputs grow from year to

need to adjust for 90% availability on both new engines, since both could run for 8760 hr yearly. When one is out for overhaul, an old engine will have to run in its place, Fig. 2, producing kwhr at a higher cost.

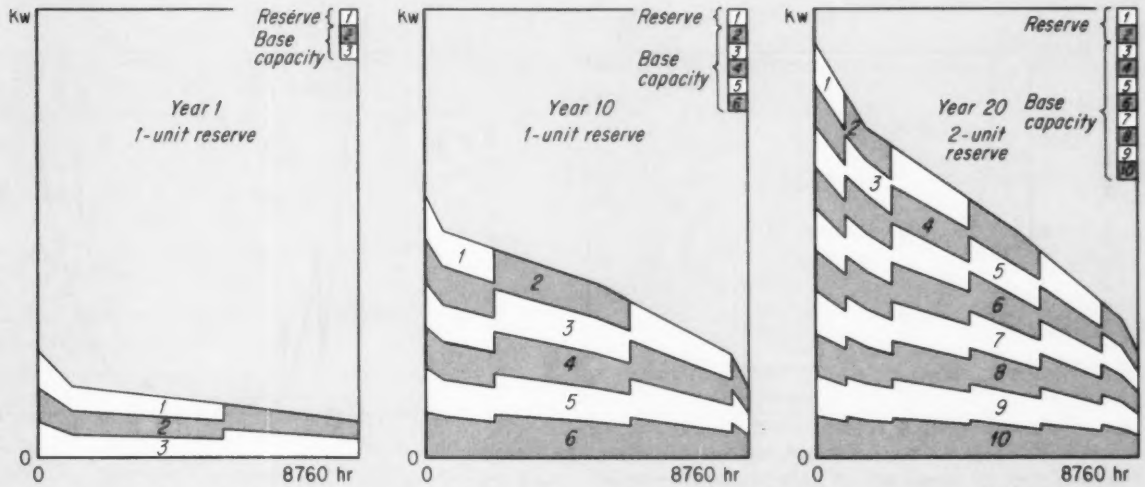
Replacing two old engines saves 170,540 − 162,880 = $7660 over the 1-engine case, so installing at least two new engines saves money for the long run.

In Case D we replace three old engines. Now, a study of the load-duration curve shows that the third new engine can substitute for the two on base when they are out for overhaul, besides being on the line for 4000 hr to carry its part of the load. In addition, there will be enough time to take out the third new engine for overhaul.

We find that replacing three engines saves 162,880 − 159,160 = $3720 a year over replacing only two engines. So it pays to replace three engines.

In Case E we replace four old engines. Again no availability correction is needed, but we find that replacing the fourth engine loses 166,890 — 159,160 = $7730 yearly.

This study suggests that we can reduce overall operating costs of the plant by replacing three of the old engines. Note that these savings are above the amortization and interest cost of the old units. These might be (3 × 1000 × 180) (0.05 + 0.035) = $45,900 yearly. They would be paid off from the normal proceeds of the overall business, which would be boosted by savings shown in this study. The key here is to recognize the costs that will be unaffected by the change.



3 Units that were base loaded in the early years of an expanding system gradually work their way to the top of the load curve as newer, more efficient units are added to increase capacity. These curves assume that base-load units have 100% availability

year along with system load. But once off the base their annual output drops quickly as they climb to the peak.

As the system matures, later units stay in the base area for more years and don't drop to as low a level as they approach the peak of load-duration curve.

We must account for this diminishing output over the lives of the alternatives we're evaluating. An estimate of the type in Fig. 3 should be made to find the annual capacity factor curve as in Fig. 2.

Next we evaluate annual total cost of the new units being added for the first year of their operation. Then the operating costs (exclusive of capital charges) should be diminished to their average over the expected life of the new units. We assume operating costs vary directly with annual capacity factors.

At this point it's customary to recognize that the *present worth* of future savings or costs is considerably less than their face value. So variations in costs are weighted according to how far they are from the present. We figure the present worth of a sum by dividing it by the present worth factor; for example:

$$W = \frac{C}{(1+i)^n}$$

where W = present worth of future sum C, i = interest rate and n = number of years hence that sum C will be realized or in hand.

Since costs vary directly as the capacity factor CF for the year, we can find the ratio of average weighted CF's to the first year's CF to find the age factor r by which to diminish the first year's cost. Table, opposite next page, shows how weighted CF's are figured. Then we convert total present worths into an equivalent constant annuity by:

$$A = W \frac{i}{1-(1+i)^{-n}}$$

continued

where A represents the equivalent average annual cost over the life of the unit in terms of CF. Then the age factor is:

$$r = A/CF_1$$

where CF_1 is the annual capacity factor for the first year of operation of the new unit. Table 1 uses a hypothetical capacity-factor variation and an 8% interest rate. For these conditions:

$$A = 569.2 \frac{0.08}{1 - 1.08^{-30}}$$

$$= 569.2 \times 0.1019 = 58.0$$

From which we can figure:

$$r = \frac{58.0}{70.0} = 0.83$$

How would we use this factor? Suppose we were comparing two units, A and B, for addition to this growing system. We find that for unit A:

Annual capital charges =	$400,000
First year's operating costs =	380,000
Total first year's generating costs =	$780,000

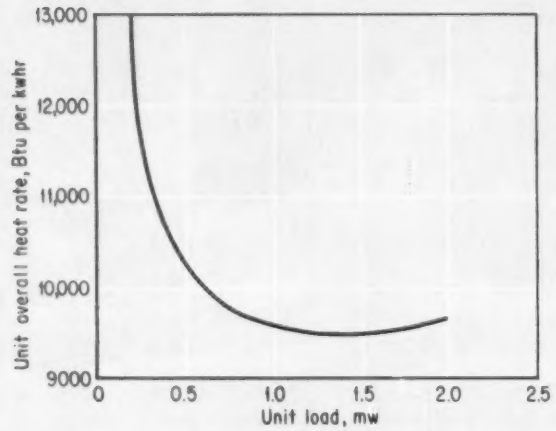
Applying the age factor to the operating cost:

Annual capital charges =	$400,000
Average annual operating cost, 0.83 × 380,000 =	316,000
Average annual generating cost =	$716,000

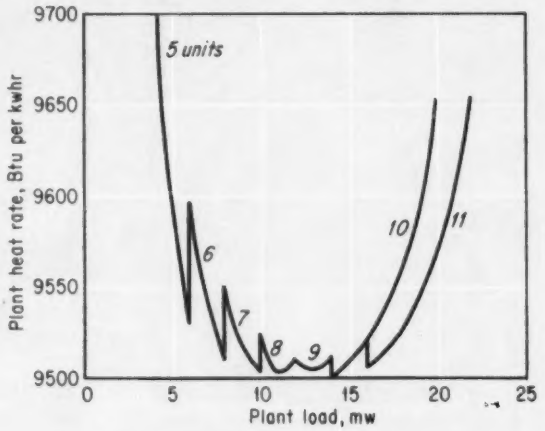
Now for unit B we find:

Annual capital charges =	$380,000
First year's operating costs =	400,000
Total first year's generating cost =	$780,000

Applying the age factor:



1 High-efficiency generating unit has flat heat-rate variation over much of its load range, which reduces station fuel cost



2 Plant heat-rate curve shows units in Fig. 1 running on 2-unit reserve. Units are added when needed to maintain the reserve

Base-load or peaking unit next?

Growing energy systems developing sharp peak demands as in Year 20, Fig. 3 on previous page, can use additional capacity in form of (1) high-efficiency base-load unit or (2) peaking unit. Choice depends on an economic study such as the following:

Power plant with ten 2-mw units has unit heat rates of Fig. 1 and plant heat rate of Fig 2. The plant is designed for a 2-unit reserve and so carries a protected peak demand of 20 − 4 = 16 mw. Another unit must be added to carry an expected peak of 17 mw.

Management decides to study two alternatives: (1) install another similar unit at $190 per kw or (2) a peaking unit costing $130 per kw and having a full-load heat rate of 18,000 Btu per kwhr.

New peak of 17 mw has a duration of 200 hr a year. Next step on the load-duration curve is 15 mw which will last 400 hr per year. Fig. 2 shows the plant heat rate with the 11th base-load unit added. Peak load at 17 mw can be carried at a better heat rate than with the existing ten units; all lower loads will be carried on ten units or fewer as dictated by the 2-unit reserve.

In comparison, if we installed a 2-mw peaking unit it would run only for the 200 hours; with ten high-efficiency units and the load-duration curve we're considering, it would seldom have to run at other times. So to compare the new high-efficiency unit with the peaking unit we only need to study operation at peak times.

No additional operating labor is needed for either unit,

Annual capital charges =	$380,000
Average annual operating cost, $0.83 \times 400{,}000 =$	332,000
Average annual generating cost =	$712,000

If we didn't recognize the variation in annual operating costs, Units A and B would appear equal on an economic basis. But with the corrected operating costs we see that Unit B is cheaper by $4000 yearly.

Age factor has a small effect here because annual capacity factor of the unit to be installed changes rather slowly. Where load grows faster on a system the age factor may drop to 0.6 and the growth must be accounted for to arrive at a rational choice. It is best to study this factor of system development—don't just assume that it has small importance. The faster the energy system grows the lower will be the age factor with greater final effect.

Present worth of annual capacity factors

Yr	CF	$\frac{1}{(1+i)^n}$	W	Yr	CF	$\frac{1}{(1+i)^n}$	W
1	70	0.926	64.8	11	48	0.429	20.6
2	72	0.857	61.6	12	44	0.397	17.4
3	73	0.794	57.9	13	41	0.368	15.1
4	74	0.735	54.4	14	38	0.341	13.0
5	75	0.681	51.0	15	35	0.315	11.0
6	70	0.632	44.3	16	32	0.292	9.4
7	65	0.584	37.9	17	30	0.270	8.1
8	60	0.540	32.4	18	28	0.250	7.0
9	56	0.500	28.0	19	26	0.232	6.0
10	52	0.463	24.1	20	24	0.215	5.2
							569.2

and maintenance costs are assumed equal. Capital-charge rate for the system is 15%, fuel costs 60¢ per million Btu.

High-efficiency unit will make an overall fuel saving at 17-mw system load of:

$17{,}000(9537 - 9513)200 = 81.5$ million Btu annually

This is an overall operating-cost saving of:

$$81.5 \times 10^6 \times 0.60/10^6 = \$48 \text{ annually}$$

Then the relative generating cost for the new high-efficiency unit figures out to:

Capital charges $= 190 \times 2000 \times 0.15 =$	$57,000
Relative operating cost =	−48
Relative generating cost =	$56,952

Peaking unit will carry about 1/11th of the 17-mw peak or 1.5 mw for 200 hr. At this level its heat rate is 20,000 Btu per kwhr. The existing ten units would carry $17 - 1.5 = 15.5$ mw at a heat rate of 9640 Btu per kwhr according to Fig. 2. This gives a plant heat rate of:

$$\frac{1.5 \times 20{,}000 + 15.5 \times 9640}{17.0} = 10{,}540 \text{ Btu per kwhr}$$

The existing ten units could carry the 17-mw load at 9537 Btu per kwhr, Fig. 2. Peaking unit then causes an annual fuel loss of:

$17{,}000(10{,}540 - 9{,}537)200 = 3410 \times 10^6$ Btu or $3410 \times 10^6 \times 0.60/10^6 = \$2046$

Relative generating cost for the peaking unit:

Capital charges $= 130 \times 2000 \times 0.15 =$	$39,000
Relative operating cost =	2046
Relative generating cost =	$41,046

So the peaking unit is the economic choice by:

$56{,}952 - 41{,}046 = \$15{,}906$ per year saving.

The saving in capital charges far outweighs the higher fuel cost of the peaking unit.

We can estimate the number of hours we can be forced to run the peaking unit for standby emergency and still have it economically equal. Average heat rate of the existing units for a year's operation will be about 9530 Btu per kwhr, from Fig. 2. The peaking unit we can assume at an average of 20,000 Btu per kwhr running at an average load of 1.5 mw.

First let's find the fuel equivalent of the $15,906 annual saving:

$$\frac{15{,}906}{0.60/10^6} = 26{,}555 \times 10^6 \text{ Btu yearly}$$

Running in place of a high-efficiency unit the peaking unit causes a loss of:

$1500(20{,}000 - 9530) = 15{,}705{,}000$ Btu per hr

Number of hours running, equivalent to annual generating-cost saving, is then:

$$\frac{26{,}555}{15.7} = 1690 \text{ hr}$$

With ten high-efficiency units in the plant it's unlikely that this many hours of emergency service will be required of the peaking unit beyond its normal peak hours of running.

To see the other side of the coin, let us find what the average heat rate of the existing system would need to be to make a new high-efficiency unit at least equal economically to the peaking unit.

Difference of high-efficiency-unit capital charges and relative generating cost of the peaking unit gives us the saving in operating costs that the former must make:

$\$57{,}000 - 41{,}046 = \$15{,}954$ annually

This saving is $15{,}954/0.60/10^6 = 27.0 \times 10^9$ Btu a year. With a load factor of 50%, total kwhr is $17{,}000 \times 0.5 \times 8760 = 74.5 \times 10^6$ kwhr. New base-load unit at 80% capacity factor will generate $2.0 \times 0.8 \times 8760 = 14{,}020$ mwhr annually at an average heat rate of about 9550 Btu per kwhr. Average heat rate of the existing units will be about the same whether they're carrying the total energy or total less the new-unit generation. Letting HR be the average heat rate of the existing units, the annual saving equals:

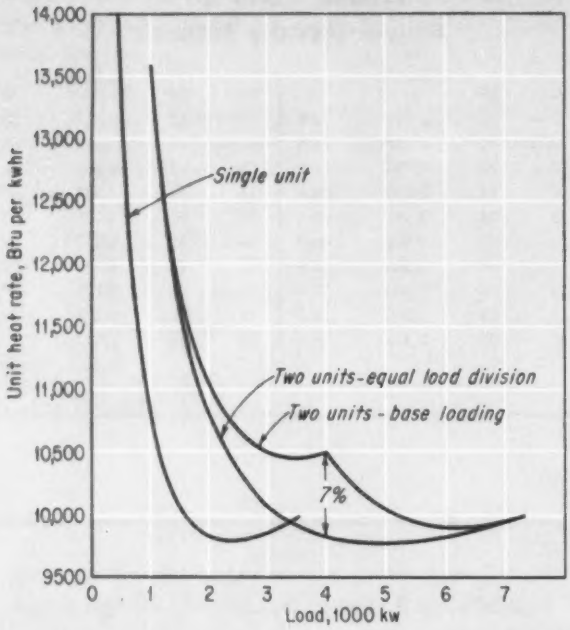
$27.0 \times 10^9 = 74{,}500{,}000\ HR$

$-(74{,}500{,}000 - 14{,}020{,}000)\ HR + 14{,}020{,}000 \times 9550$

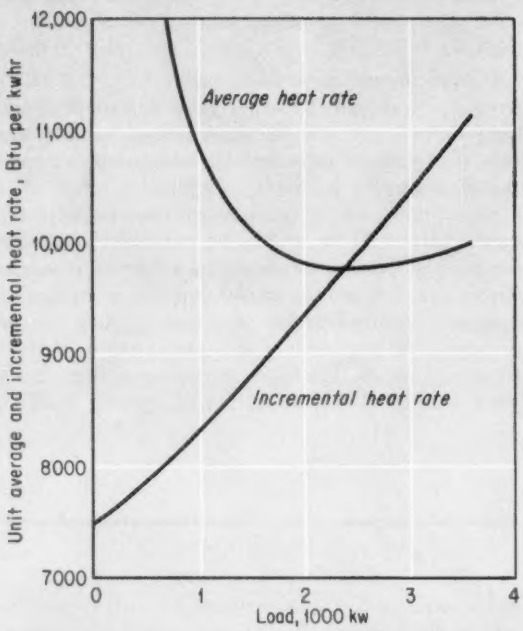
Solving, $HR = 11{,}480$ Btu per kwhr. A heat rate higher than this for the existing units makes a new base-load unit the preferred choice.

The lesson here is that a low-efficiency low-cost peaking unit can only be justified on a system that runs at high efficiency with its present load.

Knowing cost of next added unit of load saves money



1 Depending on shape of unit heat-rate curve, improper load division can raise total fuel input above the minimum needed



2 Every generating unit, regardless of its type, has an average-heat-rate curve and a corresponding incremental-heat-rate curve

Incremental rates—key to load division

How should we divide load between units working in parallel to feed a common demand? Despite extensive literature on the proper technique, many operators hold to the base-loading fallacy. First they load their most efficient unit to its full rating, then bring the next one to full rating and so on.

To see the error in this method of *base loading* let's study Fig. 1. Here the heat-rate curve of a single generating unit comes down from infinity at zero load to a best heat rate of 9780 Btu per kwhr at 2400 kw. It rises slightly to 10,000 Btu per kwhr at full rating of 3600 kw on the unit.

When we put two of these units on the line in parallel to carry a common load we get best efficiency by loading them equally; that is, each unit carries half the total load at all levels. They will then have the combined heat-rate curve labeled *Two units–equal load division.* This is a simple reproduction of the single-unit curve with the same heat rate at twice the load.

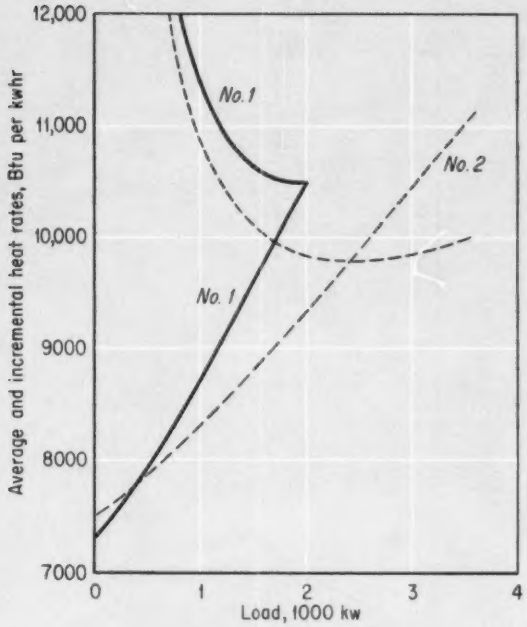
What happens when we decide to hold one unit at a minimum load of 400 kw while we bring the other up to 3600 kw and then bring the second one up to 3600 kw while the first stays at 3600? We get the heat-rate curve labeled *Two units–base loading.* Across the entire load range the combined heat rate is higher than for equal loading; where one unit reaches full rating we have a combined heat rate 7% higher than for equal loading. Each unit does not run to get the most kwhr for the least Btu. Let's study incremental rates to see why.

Every generating unit has two heat rates. The one we all know is properly called *average heat rate,* Fig. 2. It's the *total* Btu-per-hr input divided by the *total* kwhr output at any given load. But there's another one, called the *incremental heat rate,* which measures *added* Btu input needed to produce the *added* kwhr of output at any given load.

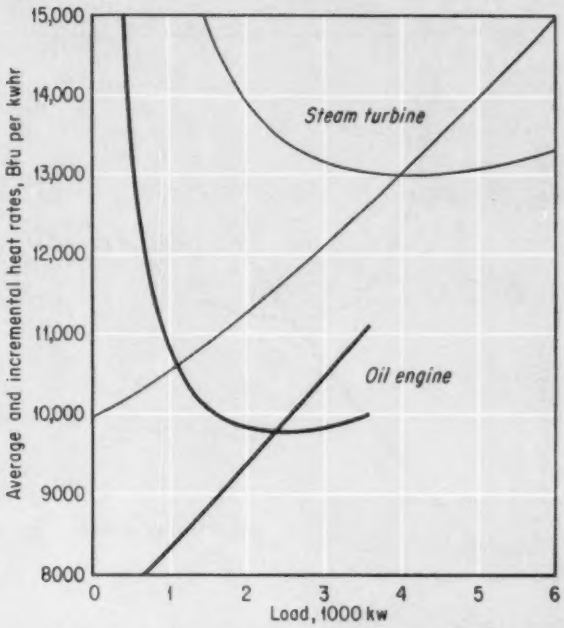
For instance, at zero load it takes a minimum Btu input to just turn over the prime mover without producing any kw. This minimum supplies all types of losses and radiation. To produce the first kw takes the Btu shown at zero load by the incremental heat-rate curve in Fig. 2—7540 Btu per kwhr. The average heat rate, though, is 7540 + total no-load input Btu, which gives us a very high *average* heat rate.

To get the second kwhr we have to put in slightly more than another 7540 Btu, because the incremental-heat-rate curve is rising. At any total load the incremental curve shows Btu that must be added to produce the *next* additional kwhr.

We find the incremental-rate curve for a prime mover from the average heat-rate curve, which should be determined by an accurate performance test run in accordance with the ASME Power Test Code for the type of prime mover. The average heat-rate curve should be plotted to a large scale, so you can read it to at least four figures—preferably five.



3 Comparative heat- and incremental-heat-rate curves for two units; curves always cross at the minimum average heat rate



4 Comparative heat- and incremental-heat-rate curves for steam-turbine unit and an oil engine depend on operating conditions

To demonstrate the method of figuring incremental heat rate we'll take a sample of the load range from 2000 to 2600 kw in 200-kw steps:

Load, kw	*Average heat rate, Btu per kwhr*	*Total input, Btu per hr*	*Increment input, Btu per hr*	*Incremental heat rate, Btu per kwhr*
2000	9826	19,651		
			1889	9445
2200	9791	21,540		
			1932	9660
2400	9780	23,472		
			1974	9870
2600	9785	25,446		

The load and average heat rates are multiplied to get total input in Btu per hr. They are listed above in thousands of Btu. Taking the differences in input corresponding to the 200-kw steps in output we have the increment inputs for 200 kw. Then, dividing each increment input by 200 kw, we get the incremental heat rate in Btu per kwhr. We can assume these apply to the midpoint of each step; for example, at 2100-kw load the incremental heat rate is 9445 Btu per kwhr, at 2300 kw it's 9660 Btu, etc. By so plotting we get the incremental-rate curve in Fig. 2. This curve is important to load division because it tells us what we have to pay for each added kwhr from a given unit.

Let's see how we use these curves in scheduling load division between units. Fig. 3 shows the average and incremental curves for two units in a plant, No. 1 with 2-mw and No. 2 with 3.6-mw capacity.

When we need only one of these units to carry load, we would take No. 2 because its average heat rate is lowest at all load levels. The average heat-rate curve helps our choice in this situation.

But when both units must operate, how shall we divide the load? The basic rule is simple: for each added kw of load produced we want to pay the minimum input in Btu. The incremental-rate curves tell us just what we pay for each additional kw from each unit. Since we don't want to pay more from one unit than from the other, we conclude that the units should be loaded *so their incremental heat rates are equal.*

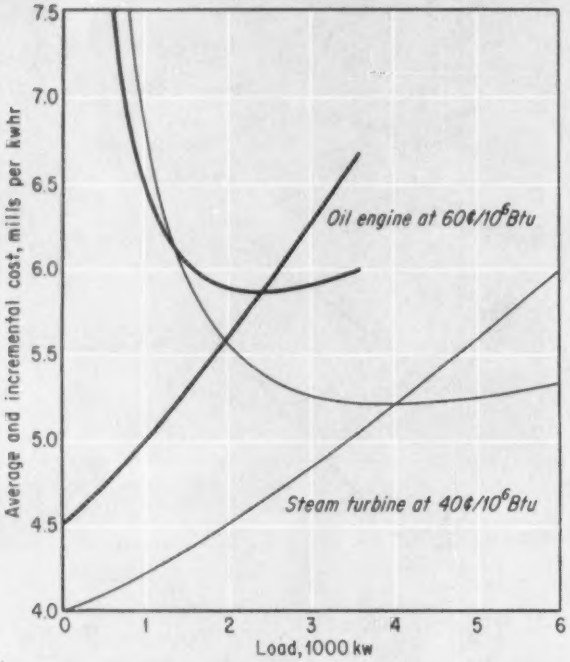
With this principle in mind let's work up a loading schedule for Units 1 and 2 in Fig. 3:

Incremental heat rate, Btu per kwhr	*Unit loading, kw*		
	No. 1	*No. 2*	*Total*
7900	540	460	1000
8500	850	1150	2000
9110	1220	1780	3000
9770	1600	2400	4000
10,500	2000	3000	5000
11,120	2000	3600	5600

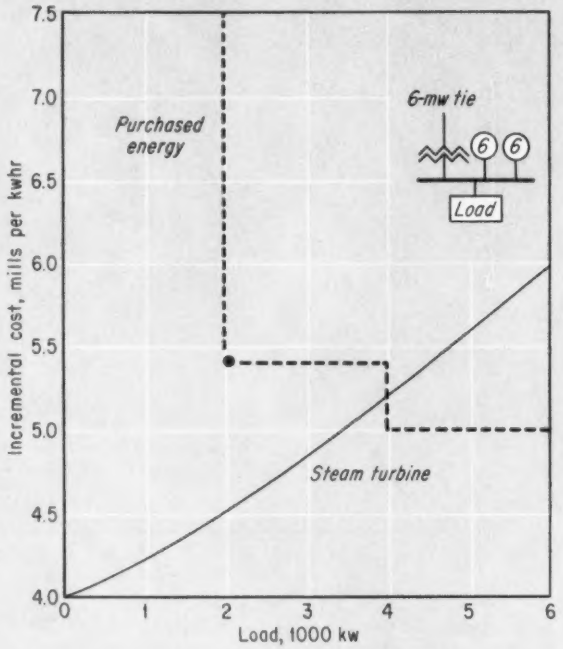
With this load schedule figured for maximum operating economy, note that less efficient Unit 1 reaches its full load before more efficient Unit 2.

Notice that in Fig. 1 the two similar units when equally loaded are running at equal incremental heat rates (IR). Now we can see why base loading is inefficient. Look at the loading table above and assume we are base-loading two units like No. 2. Following

Relative incremental cost of energy fixes proper load



5 When fuel costs differ, performance curves should be converted to mills per kwhr to place them on proper basis for comparison



6 To load units economically in parallel with a tieline, you need to chart kwhr purchase cost and increment cost for the units

this method, while we hold one unit at minimum load of 460 kw and at an IR of 7900, we are loading the other at IR way above 7900–up to 11,120 Btu per kwhr. We pay much more for added load this way than by equally loading the two units and always paying the same in each for added input to carry added load.

No matter how many units we have in a plant we divide load simply be keeping all incremental rates equal. Plot all the IR on a common graph, read off the loads on each unit for the same IR, and we have our load schedule.

Fuel cost. Heat expended is not the last word in load division—it's what the heat costs that's vital. We must aim for minimum dollar costs in running our energy systems. For example, suppose an oil engine and a steam-turbine unit run in parallel. Heat rate and IR curves are shown in Fig. 4. On a straight heat-expended basis, this would be the load-division schedule:

	Unit loading, kw		
IR	*Steam turbine*	*Oil engine*	*Total*
8300	1000*	1000	2000
9350	1000*	2000	3000
10,430	1000*	3000	4000
10,750	1250	3250	4500
10,950	1550	3450	5000
11,580	2400	3600	6000
15,000	6000	3600	9600

*Turbine minimum load

The oil engine, because of its superior efficiency, would take most of the load at lower plant levels, except for the minimum that must be put on the turbine for mechanical safety.

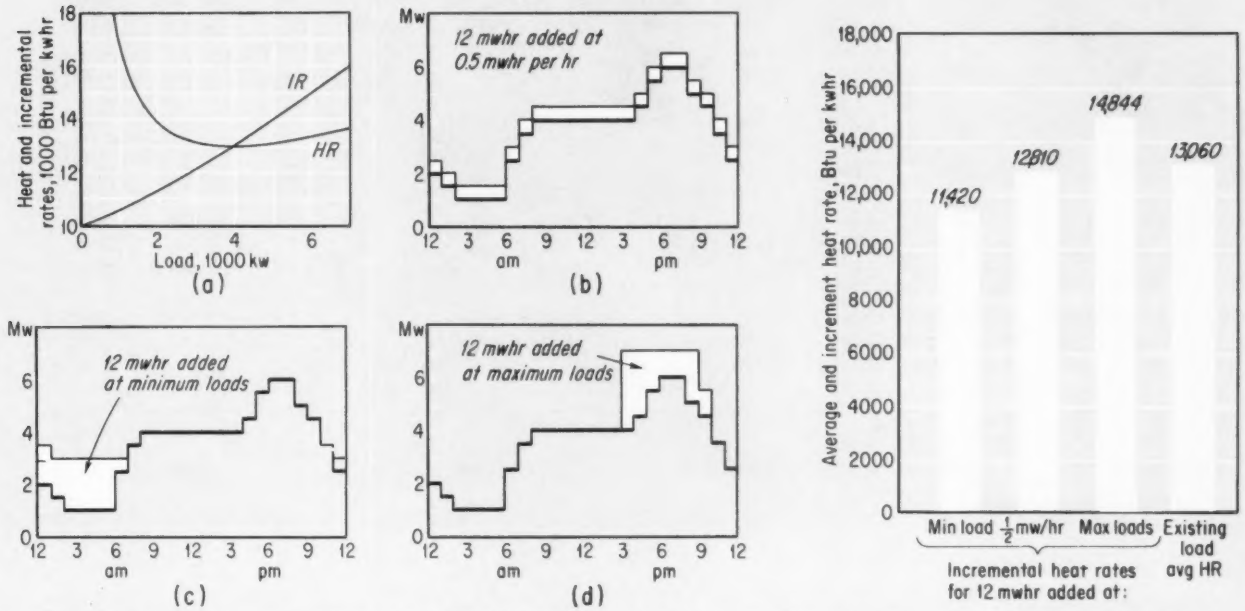
But in a plant setup of this type it's more than likely that the two units would be using different types of fuel. Suppose that while the turbine burns coal at 40c per million Btu, the oil engine uses diesel oil at 60c per million Btu.

Then, multiplying the average and incremental rates by their respective costs, we convert turbine and engine curves into average and incremental costs expressed in mills per kwhr, Fig. 5. This makes a big difference in load division, producing a schedule like this:

	Unit loading, kw		
IR	*Steam turbine*	*Oil engine*	*Total*
4.22	1000	0	1000
4.50	2000	0	2000
4.70	2600	400	3000
4.90	3200	800	4000
5.12	3800	1200	5000
5.35	4400	1600	6000
5.59	5000	2000	7000
5.84	5700	2300	8000
6.25	6000	3000	9000
6.58	6000	3600	9600

Comparing with the former table, we see that the fuel cost makes a radical change in economical load division. Now the steam turbine is favored since it's the lower cost producer of the two units. As fuel costs change with time, the load-division schedule must be updated to conform.

division for economy—in one plant or between plant and tieline



7 (a) Average and incremental heat rates of plant feeding daily load curve. (b) Generating 12 mwhr more daily by raising hourly load by 0.5 mw. (c) Generating 12 mwhr more by filling the valley. (d) Generating 12 mwhr more by broadening peak

It's also evident that should the efficiency curves of any of the units change due to wear or equipment alterations, load-division schedule will need to be refigured.

A cost concurrent with the running of any unit is maintenance needed because of wear and tear. This factor is tough to evaluate. Some engineers raise the incremental-cost curves by the average cost of maintenance in mills per kwhr to account for it. At least this favors units that perform better maintenance-wise.

Where we buy energy from another system to supplement our own capacity to supply our load, incremental rates come in handy. Fig. 6 shows the system setup with two 6-mw steam-turbine units paralleled with a 6-mw tieline to supply a load. Graph shows the incremental-cost rate of the turbines as well as cost of purchased energy.

Contract for purchased energy includes a requirement that a steady flow of energy at 2000 kw shall be bought through the tieline at all times. For this condition an increment-cost step curve for the purchased energy is used. This states that energy bought at up to 2000-kw flow costs 1.0 c per kwhr. Energy bought at loads from 2000 to 4000 kw costs 5.4 mills per kwhr and energy at loads above 4000 kw costs 5.0 mills per kwhr. This gives us the step curve in Fig. 6; the solid point shows minimum load that's always carried by the tie.

Now we have the problem of scheduling load division between the tie and the two units. As far as possible we want to carry a 6-mw reserve. For this condition we can't apply the rule of equal incremental rates, but must use the more basic rule of buying the next increment of

1—Loading schedule for tieline and two units

Load, mw				Increment cost, mills per kwhr			Total cost, $ per hr		
Total	Tie	1	2	Tie	1	2	Tie	1 & 2	Total
3	2	1.0	0				20.00	6.77	26.77
				—	4.36	—			
4	2	2.0	0				20.00	11.13	31.13
				—	4.66	—			
5	2	3.0	0				20.00	15.79	35.79
				—	5.01	—			
6	2	4.0	0				20.00	20.80	40.80
6	2	2.0	2.0				20.00	22.26	42.26
				—	4.58	4.58			
7	2	2.5	2.5				20.00	26.83	46.83
				—	4.75	4.75			
8	2	3.0	3.0				20.00	31.58	51.58
				—	4.92	4.92			
9	2	3.5	3.5				20.00	36.50	56.50
				—	5.10	5.10			
10	2	4.0	4.0				20.00	41.60	61.60
				—	5.29	5.29			
11	2	4.5	4.5				20.00	46.90	66.90
				5.40	—	—			
12	3	4.5	4.5				25.40	46.90	72.30
				5.40	—	—			
13	4	4.5	4.5				30.80	46.90	77.70
13	6	3.5	3.5				40.80	36.50	77.30
				—	5.10	5.10			
14	6	4.0	4.0				40.80	41.60	82.40
				—	5.29	5.29			
15	6	4.5	4.5				40.80	46.90	87.70
				—	5.49	5.49			
16	6	5.0	5.0				40.80	52.38	93.18
				—	5.69	5.69			
17	6	5.5	5.5				40.80	58.08	98.88
				—	5.89	5.89			
18	6	6.0	6.0				40.80	63.97	104.77

2—Comparison of heat rates for 12 mwhr added to daily load curve

Hr end	Hr	Mw	Avg heat rate	Total input	0.5 mw added every hour: Inc heat rate	0.5 mw added every hour: Inc input	12 mwhr added at minimum loads: Inc mw	12 mwhr added at minimum loads: Inc heat rate	12 mwhr added at minimum loads: Inc input	12 mwhr added at maximum loads: Inc mw	12 mwhr added at maximum loads: Inc heat rate	12 mwhr added at maximum loads: Inc input
1	1	2.0	13,908	27.82	11,450	5.73	1.5	11,873	17.81	—	———	———
2	1	1.5	14,850	22.28	11,060	5.53	1.5	11,460	17.19	—	———	———
3	4	1.0	16,935	67.74	10,700	21.40	2.0	11,270	90.16	—	———	———
7	1	2.5	13,425	26.85	11,870	5.93	0.5	11,870	5.94	—	———	———
8	1	3.5	13,040	45.64	12,750	6.38	—	———	———	—	———	———
4	8	4.0	13,000	416.00	13,230	52.92	—	———	——— (1 hr)	3.0	14,487	43.46
5	1	4.5	13,030	58.64	13,730	6.87	—	———	———	2.5	14,738	36.85
6	1	5.5	13,200	55.76	14,730	7.36	—	———	———	1.5	15,243	22.86
8	2	6.0	13,327	159.92	15,300	15.30	—	———	———	1.0	15,500	31.00
9	1	5.0	13,096	65.48	14,230	7.11	—	———	———	2.0	14,990	29.98
10	1	4.5	13,030	58.64	13,730	6.87	—	———	———	1.0	13,980	13.98
11	1	3.5	13,040	45.64	12,750	6.37	—	———	———	—	———	———
12	1	2.5	13,425	33.56	11,870	5.94	0.5	11,870	59.35	—	———	———
Totals		83.0*		1083.97		153.71			137.05			178.13
Averages		3.46	13,060		12,810			11,420			14,840	

* Sum of (mw × hr of duration)

energy at the least cost from either tieline or turbines.

Table 1 shows load division and some additional data. We start with the minimum 2-mw load on the tie and a minimum 1-mw load on one turbine for a total load of 3 mw (using the turbine of Fig. 5). Incremental rate on the tie for this condition is 5.4 mills, but on the turbine it is 4.22 mills, so we start loading the turbine in 1-mw steps. To find the average IR of the blocks of generation added, use averages of IR at each end of the block.

At 6-mw total load we have to add the second turbine to maintain reserve. We continue adding 1-mw increments to the turbines' generation until the units are running at 4.5 mw with an IR of 5.4 mills, same as the tieline. This happens at a total load of 11 mw. The moment we reach this point it is cheaper to buy energy from the tieline rather than load the turbines further, which brings us to 4 mw on the tieline at a total load of 13 mw. But then at the next step we can buy much cheaper energy from the tieline at 5.0 mills.

At this total load level it pays us to shift load among the units and carry the total 13 mw by loading the tieline to 6 mw and unloading each of the turbines to 3.5 mw. By doing this we drop 2 mw on the turbines at an average IR of 5.2 mills and replace it with tieline energy at 5.0 mills. But notice that we can't reach this lowest step of purchased energy until the total load grows to this level. Resist the temptation to load the tieline first to reach that cheap last block without watching your other costs.

Table 1 includes data on the hourly costs from the two energy sources to give the total hourly costs. You can use these to check any other method of loading, satisfy yourself that lowest-incremental-cost loading is the economical way to do it.

Cost of adding load on an existing system depends on the way it's done. To find the added fuel costs there's a great temptation to take the easy way and assume it will be at the average overall heat rate of the system with the current load. This can lead to gross error, if we don't appreciate the significance of incremental cost or heat rate in figuring overall costs.

Fig. 7*a* shows average and incremental heat-rate curves of a plant serving the loads shown in *b* to *d*. In Fig. 7*b* we add 12 mwhr to the system load, by raising the load by 0.5 mw at every hour.

In table 2 we list the current load and figure the average heat rate for the 24 hr which equals 13,060 Btu per kwhr. For the increment inputs of 0.5 mw we use the increment heat rates of 7*a* at the different load levels. Average heat rate for this added load is 12,810 Btu per kwhr, about 2% lower than the system average heat rate.

In Fig. 7*c* we add the 12 mwhr by "filling" the valley of the load curve. Table 2 shows that the added kwhr are generated at an average increment heat rate of 11,420 Btu per kwhr, 12.5% less than the 13,060 level.

In Fig. 7*d* we add the 12 mwhr all at the peak of the load curve at an average increment heat rate of 14,840 Btu per kwhr, 13.6% higher than the average 13,060 Btu.

To sum up: While most of our discussion centered on power-plant generation, *all* of the principles we covered apply to *any* type of energy system—both design and operation. We've given a condensed review of basic energy-system economics and their relations to practical systems; for more complete treatment see *Power Station Engineering and Economy* by Skrotzki and Vopat, 750 pp, $12.50, McGraw-Hill Book Company.

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GEORGI M MALENKOV, then U.S.S.R.'s Minister of Power Stations, greets Shelton Fisher at start of 1956 interview

How close have the Russians come to the goals set forth by Malenkov five years ago, when *POWER*'s Shelton Fisher made his firsthand report on . . .

Soviet power today

By ERNEST CONINE, McGraw-Hill Moscow Bureau

Slightly more than five years have rolled by since Shelton Fisher, then POWER's publisher, brought back from the U.S.S.R. an appraisal of the Soviet power situation as it stood in the summer of 1956. The facts on which his report was based came from visits to Russian plants, discussions with key members of the Ministry of Power, and a unique personal interview with Georgi M Malenkov, who had been Premier of the U.S.S.R. and was at that time Minister of Power Stations.

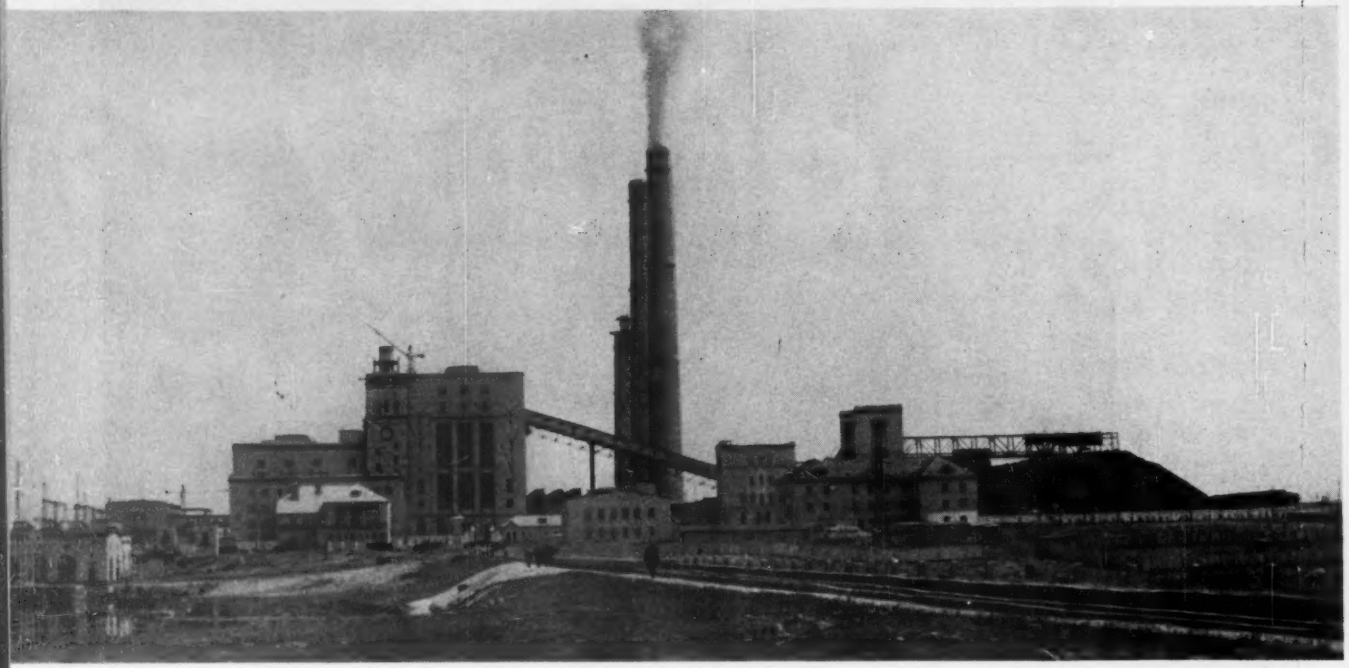
In the course of that interview, Malenkov made a number of predictions regarding power developments, many of which were keyed to the Sixth 5-Year Plan, then in its first year and scheduled for completion at the end of 1960. Although this plan was abandoned at the end of 1958 and replaced by a 7-Year Plan to cover 1959 through 1965, it occurred to POWER's editors that an effort should be made to measure the extent to which Malenkov's 1956 goals had been realized.

After months of waiting, it became apparent that an interview with an authoritative official of the Ministry of Power Stations was not to be forthcoming. Thus the report on Soviet power that follows is based on published data from a wide variety of "official" Russian sources.

Before discussing progress in specific areas covered in the Malenkov-Fisher talks, we should point out that the current 7-Year Plan involves a major shift of emphasis in Soviet power planning. As stated by I T Novikov, Minister of Power Station Construction: "The main direction of power-generation development during 1959-1965 will be preferential construction of thermal stations burning cheap coal, natural gas, mazut [petroleum residue]."

Speaking of this decision, Premier Nikita Khrushchev put the emphasis on time: "Hydroelectric stations would be better if they could be built faster. But at this stage, thermal stations are better, as it takes less time to get them going." To this consideration, apparently overriding to Khrushchev, Novikov adds that thermal stations make the most effective use of capital.

With this shift to emphasis on thermal plants, approximately 80% of the kwhr generated in 1965 are expected to be fuel-produced. At that time, natural gas will account for 17% of power-station fuel consumption, compared with less than 5% in 1955 and 10.7% in 1958. Oil is to account for 12.3% of power-station fuel in 1965, up from



Still a question: When will Cherepets Station reach 1000-mw capacity?

5.9% in 1958. Although growth in coal use will move up only slightly from the 1958 figure, it will make up 70.5% of all power-plant fuel in 1965.

At the beginning of the 1956 talk with Malenkov, Fisher asked about the largest steam stations in the U.S.S.R. and the largest generating units. Malenkov replied "In four to five years we will have five plants of 1200 to 1500 mw." At a later point in the conversation he underlined the trend to larger stations by saying, ". . . we have found that we can build a station of 1,200,000 kw for 25% less than we can build four stations of 300,000 kw. And we . . . also save about 25% in time."

Large stations still loom important in Soviet planning but in Oct 1960, A P Rozhdestvenskiy, Engineer Chief Specialist of the Ministry of Power Stations, reported that the largest plant at that time had a capacity of 900 mw. "During the next two years, however," he went on to say, "three stations will already have capacities of 1-million kw and over."

He may well have been referring to two stations whose first units started up late last year, and perhaps to Cherepets, photo above and box at right. In Dec 1960, the first 200,000-kw unit of the Zmiyevka Thermal Power Station in the Kharkov region of the Ukraine went into operation. This natural-gas-fired plant is expected to reach a total capacity of more than 2-million kw by the end of the 7-Year Plan in 1965.

Also last December, the first stage of the Baltic Station started up. When completed by 1965, total capacity is scheduled at 1,625,000 kw. This shale-fired station is located near Estonia's huge deposits.

Early this year, construction started on the Krivoi Rog Station in the Ukraine, where the first 300,000-kw unit is to be commissioned by the end of 1963. The initial 1.2-million-kw stage is to be completed by 1965; total capacity of 2.4-million kw will be reached in the years that follow. Also slated to use the new 300,000-kw turbine-generators are two other stations begun this year and planned for 2.4-million-kw each. One is the big Konakovo Station on the banks of the Volga near Moscow, designed to use either oil or natural gas.

The current 7-Year Plan emphasizes extensive utilization of the huge deposits of cheap brown coal in Siberia. Among the 40 big thermal plants in the plan, half of which have scheduled capacities ranging from 1 to 2.4 million kw, Nazarovo, Tom-Usinsk, Belovo, Irsha-Borodino are all in Siberia. And here, too, there have been complaints of delays. Last February, for example, *Tass* reported that the first 165,000-kw unit at the 1.2 million-

In the 1956 interview, Malenkov told Fisher, "You will see one of our newest plants at Cherepets. It is not of that size now, but we have plans to add units to it and it will probbably exceed 1,000,000 kw after 1960."

At Cherepets, photo above, Fisher found two 150,000-kw units in operation, with another of the same size being installed. Steam conditions were stated to be 180 atmospheres and 570 C (approximately 2700 psi, 1060 F).

The Soviets have announced plans for installing one or more 300,000-kw machines at Cherepets to secure operating experience. Exact status isn't known, but station capacity clearly has not yet exceeded 1000 mw.

kw Nazarovo Station in Krasnoyarsk Territory was due to start up but it is apparently not yet in operation. This station is built virtually on top of large brown coal deposits; fuel will be fed by conveyors directly from a mine 300-yd away.

The 300,000-kw turbine-generator, too, seems to be waiting in the wings. In his talk with Fisher, Malenkov committed himself only to the statement "This year our manufacturing industry will begin to make turbine-generator units of 200,000 kw." In an article two years ago, Novikov spoke of the design of generating units of 100, 150, 200, 300 and 600 mw. According to a *Tass* report of last May: "the biggest steam turbines in the U.S.S.R. at present have a capacity of 200,000 kw."

In his Oct 1960 article in *Teploenergetika,* A P Rozhdestvenskiy speaks of the construction of 300,000-kw units at supercritical conditions of 240 atmospheres and 580 C (approximately 3420 psia and 1075 F). Part of the experience on which these designs are based is an experimental installation at the All-Union Heat Engineering Institute which has been operating for ten years at 300 absolute atmospheres and 650 C. This is probably the boiler to which Malenkov referred in his 1956 interview with Shelton Fisher. At that time Malenkov said:

"We have one test boiler here in Moscow, developing pressure of 300 atmospheres (4400 psi). It is not generating electricity; it is for testing valves, piping and other accessories. We know that this is in the direction of progress, these higher pressures. But I would not say pressures of this size are within the near future in Russia."

Experience on which the large supercritical designs are based comes also from a 50,000-kw unit with throttle steam at 210 absolute atmospheres, 500 C and 30 absolute atmospheres backpressure. Rozhdestvenskiy says such a unit was installed to modernize the previously built large electric station at Chelyabinsk.

Whether any large supercritical units are actually in operation is a question. According to information at the Exhibition for Economic Achievements, a thermal power station in operation near Moscow has 100,000-kw generating units with primary steam conditions of 315 atmospheres and 655 C (approximately 4600 psi and 1210 F). But *Tass* reported last March that the Kharkov Turbine Works had started manufacturing "the first Soviet steam turbine of 100,000 kw with supercritical parameters." It cited a steam pressure of 300 atmospheres and a temperature of 650 C. The chief engineer of the plant said development of this turbine would solve "all problems involved in designing units up to 1.2 million kw, operating at these and even higher parameters."

Last December Novikov said, "a superpowerful 800,000-kw turbine is now on the drawing boards." In this connection, the chief designer of the Kharkov Turbine Works says "the next stage" in that plant's work will be development of a steam turbine with a capacity of 800,000 kw, designed to operate at steam pressure of 300 to 400 atmospheres. Technical design is expected to be similar to that of the 300,000-kw units.

The Elektrosila Works in Leningrad meanwhile has begun manufacture of generators of more than 300,000-kw capacity. The Soviets say these gas- and water-cooled generators are the same size as a conventional 150,000-kw generator. Nikolai Ivanov, chief designer, says U.S. firms have been designing such units for ten years while the Soviets began only five years ago. Hence he claims "we have already caught up with the Americans in per-unit power." He says the Soviet generator, rated up to 320,000 kw, weighs 20% less than its American counterpart.

Russia's nuclear-power program, as might be expected, is kept more under wraps than any other phase. The only nuclear-power plants that have been publicized lately are the original big station of 600,000 kw, which reached full power in 1958, and two more now nearing completion. The first of these is a 100,000-kw graphite-moderated water-cooled reactor utilizing nuclear superheat, near Beloyarsk in the Urals. Original plans called for a station consisting of four 100,000-kw reactors; it is not clear when or whether the other three will be built. The second of the two units reported nearing completion is a pressurized-water-reactor station at Novo Voronezh. The 210,000-kw reactor will supply three 70,000-kw turbines. Ultimately the station is to have two reactors and a total output of 420,000 kw.

Delays and defects. It appears that all is not well in the power construction program. There are two basic problems: behind-schedule construction, particularly of thermal plants, and slow or low-quality manufacture of thermal power equipment, particularly boilers and auxiliaries. A July 1960 *Pravda* story said: "Generally speaking, the task of putting new capabilities into operation sooner is one that faces all branches of the economy. And as regards power-station construction it is a particularly pressing one." And a year later *Ekonomicheskaya Gazeta* said "according to data for the first five months of this year (1961), considerably less thermal-power-station capacity was put into operation than planned."

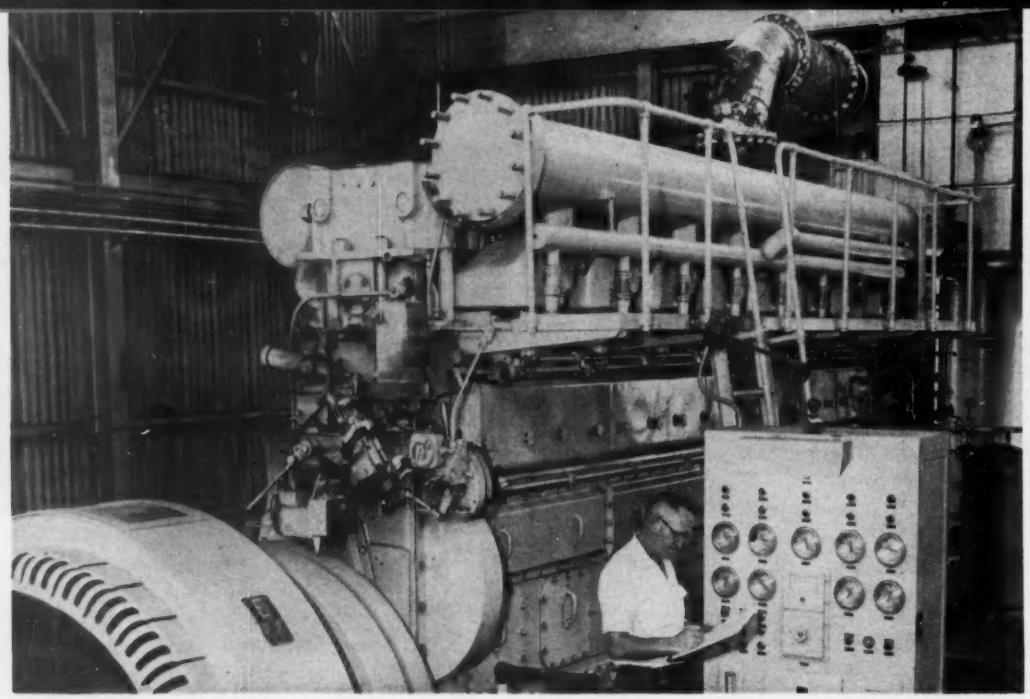
Soviet press stories make it clear that capital construction is lagging somewhat as a whole, not only the power field. Plants to produce prefabricated ferroconcrete components—on which the Soviets depend for rapid construction of thermal stations and other projects—have been built more slowly than planned. Also, design organizations are blamed for tardy delivery of necessary plans.

Ekonomicheskaya Gazeta, investigating why delivery of equipment for Cherepets Thermal Power Station and others was delayed, found that high-pressure tubing hadn't even been produced as late as last April. Another story complained that proper insulation materials and rotor windings hadn't been produced.

In an editorial last January, *Ekonomicheskaya Gazeta* stated that defects in power equipment are often discovered only when the machinery is being assembled at the site. Work stops until the defects can be corrected on the spot. Quality is especially low in the production of boilers, it was noted.

Most of the critics seem to agree that while designs are good, quality of manufacture is bad. Observers note that thermal power stations—where most difficulty is being encountered—are depended on for most of the planned new capacity. Hence it is conceivable that the Soviet program will run into serious trouble.

EDITOR'S NOTE: *An upcoming second article by Ernest Conine will review Soviet progress in hydroelectric power and in long-distance high-voltage transmission.*



POWER ENGINE in Midwest electric-generating plant can run on straight oil as a conventional diesel engine, on gas with pilot oil or, after some minor changes have been made, on straight gas with spark ignition

Is firm gas available to run your oil-gas-diesel plant for long periods? If so, investigate engines that convert readily to spark ignition. You'll find that . . .

Spark-firing straight gas cuts dual-fuel-engine heat rate

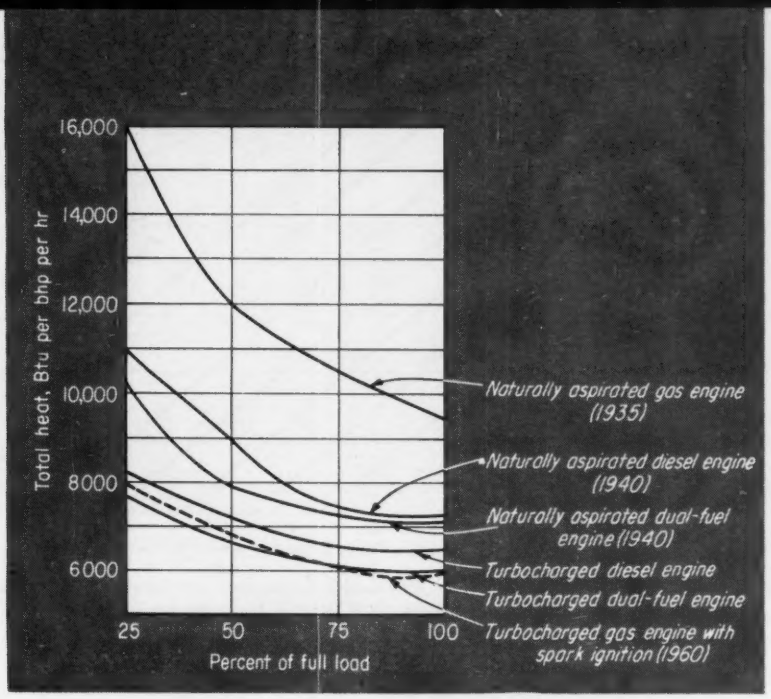
By W M KAUFFMANN, Worthington Corporation

Relative costs and availability of various power-engine fuels are constantly shifting. To buy the cheapest Btu's for his energy system, the alert engineer finds he must keep his mode of operation under continuing review. Besides the price of fuel, fixed charges, labor, maintenance and investment affect the economics of diesel-power generation. But fuel delivered at the plant represents the largest percentage of net cost per kwhr on the final tally sheet.

To keep down power costs by using the lowest-priced fuel available, engines have been developed capable of running on gas or fuel oil or a combination of the two. The familiar dual-fuel engine can do this, burning oil alone or using up to 97% gas with oil injected for pilot purposes only. If pilot oil can be eliminated, even lower operating costs are possible.

Chart 1 shows progress in power-engine economy over the last 25 years. Development of turbocharging has contributed greatly to these gains, but for near-full-load operation, spark-fired gas achieves heat rates below 6500 Btu per hphr. This fact has fostered development of a power engine capable of 3-mode operation (*tripower*, as we call it at Worthington): (1) straight diesel operation on oil (2) dual-fuel on oil and gas (3) straight, spark-fired gas. Before we look into the relative economics involved, let's trace the development of this latest engine.

In the mid-1930's, so-called *convertible* engines became available. Conversion began by inserting water-cooled cast spacers between cylinder liners and heads to reduce diesel compression ratios of 12.5:1 down to 8:1 for spark-fired gas operation. Spark plugs were placed horizontally and at diametrically opposite points in the spacer rings. A gas-air-mixing valve attached to the intake manifold and a battery timer installed at the camshaft completed the picture. But this field conversion generally took about eight hours. The need for faster,



1 Progress in power-engine economy over the last 25 years shows effect of turbocharging and high-load gain with spark-fired gas. Relative fuel costs accentuate the picture

less costly conversion was evident to minimize downtime.

When spark-ignition gas operation at diesel compression ratios had developed beyond a laboratory curiosity, the way was open to develop a fast conversion method and take advantage of firm gas availability to cut operating cost. A dual-fuel engine quickly convertible to spark ignition would have to meet these specifications: (1) operation at diesel compression ratios (2) quick replacement of fuel-injection nozzle and holder assembly with spark plug and ignition coil (3) interchangeable gas-admission systems (4) magneto or ignition generator coupled to engine drive with minimum mechanical change and (5) optimum turbocharger configuration for all modes of operation. This, then, is the design basis of today's engine capable of 3-mode operation with minimum field work.

Spark-plug designs now available permit ready interchange with injection nozzles. Plug threads into the upper portion of a patented tube-holder device. Entire assembly is then clamped into the cylinder head by the same device that would normally hold the injection nozzle. Other accessories required for any one of the three operating modes can be installed on the original engine, connected or not depending upon operation.

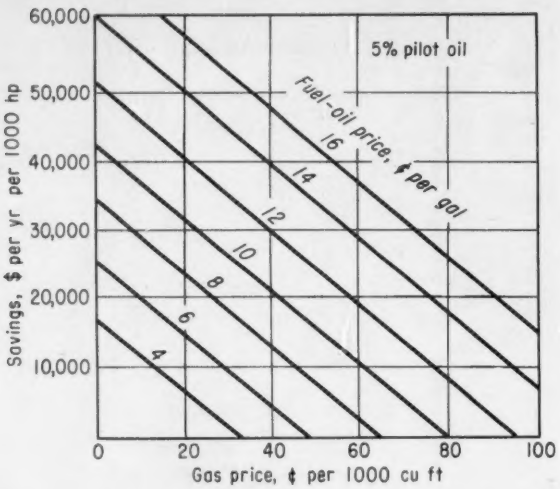
Regulation response differs among the three modes. Speed-governing characteristics of diesel, dual-fuel and spark-ignition operation are not determined merely by governor's ability to respond to load and speed changes. Since the fuel for gas-burning engines must be mixed before it enters the cylinder, there is a time lag before crankshaft receives the new torque level. Therefore, steady-state regulation is slightly poorer for gas than for straight diesel operation. Average variation runs about 0.12 of a cycle for diesel, 0.15 for dual-fuel and 0.20 for spark-ignition gas. Of course, if closer limits of regulation are necessary, suitably designed flywheels, load-sensing governors or specially constructed generator components will do the trick.

Some specific economic gains are possible if you're set up to run on straight gas. Remember that these are based on firm gas availability and a power engine specifically designed for the three types of operation.

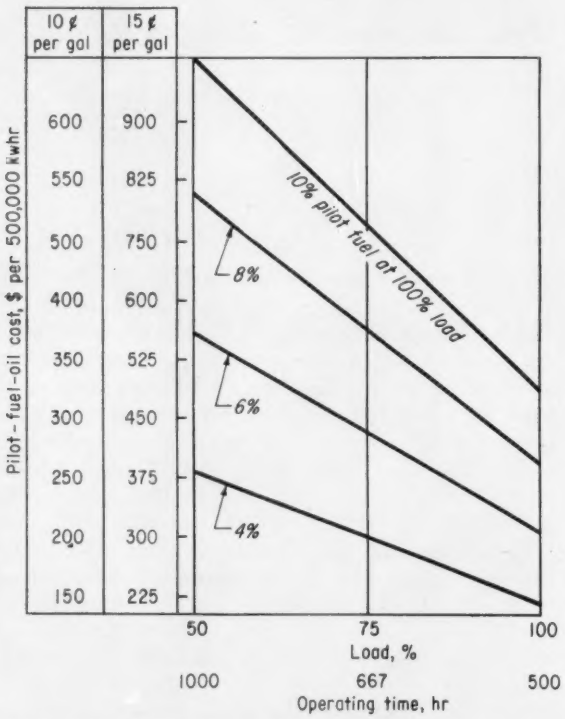
As we said, fuel costs are the major expense in power production, and for this reason we are interested in relative costs per million Btu of the various fuels. The fuels have fairly constant high and low heat values; differential comes about because of the burning of hydrogen to form water vapor and represents the heat of vaporization.

High heat value is used in determining fuel-consumption guarantees and performance comparisons for fuel oils, and so it comes into our figures for diesel and dual-fuel operation. Generally the low heat value is used for gaseous fuels; in the case of natural gas, for example, this runs approximately 10% less than the high heat value. On the other hand, since gaseous fuels are normally purchased on the basis of the high value, power costs are figured in accord with ASME Oil and Gas Power Div Subcommittee report of 1959.

Chart 2 shows dual-fuel operation savings over straight oil operation for various gas and fuel-oil prices. Chart 3 shows pilot-oil costs for 500,000 kwhr of dual-fuel generation based on various percentages of pilot oil. Proportion of pilot oil is, of course, a function of engine design. In some cases the full diesel-injection nozzle can be cut down to about 10% for dual-fuel operation; below this value a fine nozzle must be substituted to gain maximum dual-fuel economies. In other cases combination nozzles with dual-plunger injection pumps provide low



2 Check savings of dual-fuel operation over straight oil engine. Diesel consumes 0.375 lb, dual fuel 6500 Btu of fuel per hphr



3 Dual-fuel engine uses a constant quantity of pilot oil regardless of load, so relative costs go up during light-load operation

pilot-oil flows without needing any physical change.

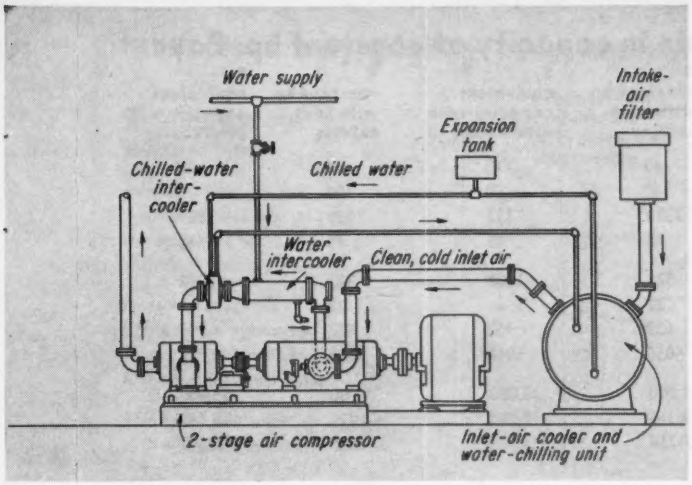
Total operating expenses for all three modes are tabulated at right. Of course fuel costs vary with locality and seasonal change, but typical values taken from the 1960 REA Survey show that diesel fuel oil averaged 75.9¢ per million Btu and fuel gas averaged 22.5¢ per million Btu. Average performance data in terms of net Btu per gross kwhr are shown for all three operating modes.

Significant saving, when you're considering straight-gas operation, is the one between dual-fuel costs and spark-ignition-gas costs. In terms of fuel, you save 0.31 mills per net kwhr; in terms of plant operation this increases to 0.35 mills per net kwhr due to slight reductions in lube oil, operating labor and maintenance. Data is reppresentative of a plant averaging 3000- to 12,000-kw load capacity, but it's probably fairly consistent for larger-output power plants.

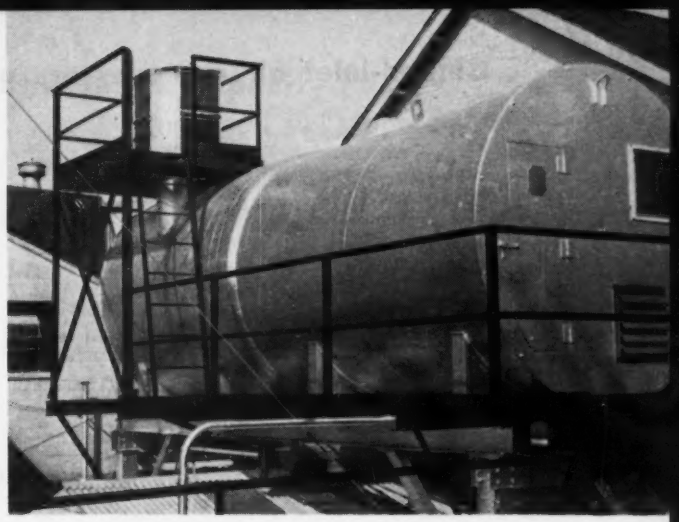
Check possibility of 3-mode operation whenever new capacity is to be installed. The operating savings are there—if you can take advantage of them. The factor you will probably be least able to control is availability of firm gas. But more and more, underground storage is supplying cities far removed from gas pools. Firm gas in your locality may be a reality already or may become so within the foreseeable future. If so, an engine designed for easy conversion to straight-gas spark-fired operation becomes an attractive consideration in your power-plant planning for future growth.

Spark-fired gas cuts operating costs

Mode of engine operation:	diesel	dual fuel	spark-fired gas
Oil cost, ¢ per million Btu	75.9	75.9	—
Gas cost, ¢ per million Btu	—	22.5	22.5
Ratio of oil to gas	100 to 0	6 to 94	0 to 100
Net Btu per kwhr	10,300	9600	9600
Operating expense, mills per net kwhr			
Fuel	7.80	2.47	2.16
Lube oil	0.21	0.18	0.17
Operating labor	1.15	1.01	1.00
Maintenance	1.02	0.92	0.90
Total	10.18	4.58	4.23



TWO-STAGE-COMPRESSOR SYSTEM shows interstage chiller in series with normal cooler as well as inlet-air chiller. Refrigeration machinery can be remote or integral with inlet-air chiller



INLET-AIR CHILLER at large glass plant is self-contained outdoor installation. Air-inlet and chilling section, far end, is fully insulated. Two 25-hp compressors, near end, supply refrigeration

Hold down compressor power needs with chilled inlet air

Feed your compressed-air plant with air at winter temperatures and it'll run at winter capacity all year 'round. Added benefit: no maintenance costs tracing to condensation

By W E MOLLENAUER, Industrial Engineer, Short Hills, N. J.

Engineers who run large compressed-air systems have long realized that they operate much more economically in winter than during the hot summer. In fact, it is frequently possible during the coldest months to actually shut down part of their compressor capacity and still meet maximum plant needs. This results from a simple fact of physics: with colder, denser winter air, more pounds of air are packed into a cubic foot of intake volume. The compressors need less power.

All things being equal, then, it would be advantageous to use cold inlet air the year around. The immediate stumbling block would seem to be cost of refrigeration equipment to chill the large air volumes involved. Sample evaluations, however, show that payout time rises only slightly over equivalent unchilled capacity. But before we see how these costs work out, let's briefly check over some other factors involved—both the obvious and the relatively obscure.

The conventional industrial aftercooler does remove excess moisture from the compressed air, but the best it can do is reduce moisture to the point of saturation —no lower. Subsequent cooling in air-distribution lines brings out additional moisture which can corrode the air line. Corrosion products, especially when mixed with oil, become first-class abrasives and can quickly damage air-operated precision equipment. In an effort to control this condensation or remove the water, traps, drop legs and filters are often installed near the use point. But nevertheless, compressed air throughout the system is at least saturated; any temperature drop brings out moisture.

Another disadvantage of an aftercooler to control moisture is the very significant air shrinkage that goes along with the cooling process. Example: if the aftercooler reduces 300-F air, as compressed, to 100 F for distribution, there is an automatic 26% reduction in volume. In addition, power required to compress the air in the first place is converted to heat, and then a large part of this valuable heat of compression is thrown away with the cooling water in an aftercooler.

To get full thermal benefits from a compressed-air system, it is a good idea to raise air-use temperatures as high as possible, consistent with the processes served. Table 4 shows volume gains and losses as functions of inlet temperatures and a use temperature of 190 F.

Remember that figures in table 4 are based on *temperature* gain and loss only. Besides temperature-based fluctua-

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Chilled-inlet air compressors gain in capacity at constant hp. Payout

1—Single-stage evaluation	1 original installation with aftercooler	2 constant hp with inlet chilling	3 equivalent capacity with aftercooler	4 constant hp with inlet chilling	5 equivalent capacity with aftercooler
Inlet-air temperature, F	70	40	70	40	70
Average air-use temperature, F	70	140	70	190	70
Air delivery, cfm	6000	7333	7333	7939	7939
Discharge pressure, psig	45	45	45	45	45
Air-compressor hp	825	825	1008	825	1092
Refrigeration-system hp	—	22	—	22	—
System power needs, kw	615	632	752	632	815
Annual power consumption, 1000 kwhr	4924	5055	6016	5055	6520
Additional equipment cost, $	—	33,000	18,000	35,000	25,000
Annual operating cost, $	56,621	60,316	70,264	60,436	76,480
Air cost, $ per 1000 cu ft	0.01966	0.01714	0.01996	0.01586	0.02007
Savings in terms of:					
Air cost, $ per 1000 cu ft	—	0.00282	—	0.00421	—
Operating cost, $	—	9926	—	16,043	—
Payout time for chilling over adding ambient capacity, yr	—	1.5	—	0.62	—
or					
Savings in terms of:					
Additional air available, cfm	—	1333	—	1939	—
Approximate cost of equivalent compressor capacity, $	—	18,000	—	25,000	—

tions, more volume loss results when moisture is removed after compression, as it is in an aftercooler. This acts to reduce rated output of a compressor even further—it may well amount to from 1 to 5% of total capacity. Actual size of the loss depends upon humidity of the atmospheric inlet air—the higher the humidity, the greater the loss.

When you're supplying the compressor with chilled inlet air which has its moisture content automatically reduced, there is no need from a condensation viewpoint for reducing air temperature in an aftercooler. And because there's no condensation, compressor maintenance is reduced at lower operating temperatures.

Some typical evaluations will show how chilled inlet air stacks up in both single and multistage compressed-air systems. Single-stage evaluation, table 1, lists in column 1 the operating characteristics of an installation taking ambient air on the inlet side and aftercooling it to ambient again. Compare column 1 to 2 and 3 as a group for 140-F air-use temperature and to 4 and 5 as a group for air used at 190 F. When air-compressor horsepower is held constant at 825, column 2 shows a gain of 1333-cfm effective capacity with inlet cooling to 40 F. Payout time for chilled-inlet-air equipment over the cost of providing this added capacity with an ambient-inlet-air scheme, column 3, stays as low as 1.5 yr. In condition 4 we repeat this evaluation process for 190-F air-use temperature. Here the added capacity is of course higher—1939 cfm—so payout time is considerably reduced.

For our multistage evaluation, table 2, we introduce another factor—chilled intercooling alone, or chilled inlet and intercooling in combination. Again column 1 is a normal installation with ambient inlet air and inter- and aftercooling. Then columns 2 and 3 reflect chilled intercooling alone with an air-use temperature of 190 F, and columns 4 and 5 reflect chilled inlet and intercooling with the same relatively high air-use temperature. In both cases the extra air available is shown, together with increase in payout time over providing this additional air capacity without chilling.

When we talk about multistage air compression, another factor comes in: where is the best place to remove moisture from the air? At a given temperature, air at elevated pressure will not hold as much moisture as it will at atmospheric pressure, so moisture should be removed at the point of highest pressure. This means that for *moisture-removal purposes only*, cooling should come after compression. But looking back to our previous evaluations we can see that from an overall cost-of-air standpoint, volume shrinkage makes moisture removal after compression unattractive.

Interstage pressure can be the point of moisture removal in a multistage machine. An intercooler is usually already there, so we can add a second heat exchanger and chill the intercooling water to obtain cold air before the second compression stage. Or a second chilled-water intercooler can be installed in series with the normal intercooler. Example: in a 2-stage air compressor discharging at 100 psig we can use the interstage pressure of about 30 psig as a point of moisture removal and chill interstage air to 35 or 40 F. Resultant dew point in the 100-psig air will be 60 F, table 3. If the high-pressure cylinder size can be reduced, giving a higher interstage pressure, we can drop the dew point even lower in the 100-psig final air.

Let's convert this compressed-air dew point to its equivalent at atmospheric pressure—when the air expands. Here we find that our 60-F dew point becomes 11 F. Expressed

time rises only slightly over equivalent unchilled capacity

2—Multistage evaluation

	1 original installation with inter- and aftercooler	2 constant hp with inter-chilling	3 equivalent capacity with inter- and aftercooler	4 constant hp with inlet and inter-chilling	5 equivalent capacity with inter- and aftercooler
Inlet-air temperature, F	70	70	70	40	70
Average air-use temperature, F	70	190	70	190	70
Air delivery, cfm	1586	1965	1965	2090	2090
Discharge pressure, psig	100	100	100	100	100
Air-compressor hp	317	317	393	317	418
Refrigeration-system hp	—	12	—	21	—
System power needs, kw	237	245	293	251	312
Annual power consumption, 1000 kwhr	1892	1963	2346	2006	2494
Additional equipment cost, $	—	8500	9000	20,000	13,000
Annual operating cost, $	21,758	32,087	27,514	24,264	29,466
Air cost, $ per 1000 cu ft	0.02858	0.02448	0.02917	0.02419	0.02937
Savings in terms of:					
Air cost, $ per 1000 cu ft	—	0.00469	—	0.00538	—
Operating cost, $	—	4424	—	5397	—
Payout time for chilling over added ambient capacity, $	—	0	—	1.3	—
or					
Savings in terms of:					
Additional air available, cfm	—	379	—	504	—
Approximate cost of equivalent compressor capacity, $	—	9000	—	13,000	—

in terms of relative humidity, this comes out to 39%. Since it isn't likely that these conditions will be hit within the compressed-air system, we have avoided the possibility of condensation. Additional advantage of a chilled intercooler over cooling after compression: heat of compression from the last-stage cylinder remains in the air and increases air volume available at the use point.

Interstage chilling alone gives us a nonstandard high-pressure-cylinder size. So in an existing installation, interstage chilling by itself will probably be out of the question. But if both inlet *and* interstage air are chilled to the same low temperature, standard-sized cylinders can be used; normal interstage pressures result.

Inlet-air chilling can add significant volume to your compressed-air capability. In some cases it might even let you meet growing plant-air needs without installing additional compressors.

Of course to gain maximum benefit and economy in your compressed-air system from inlet-air chilling you should review use temperatures. You'll find in many cases that higher use temperatures are in the cards.

Many types of air-operated production machines are actually capable of running at much higher temperatures than you would first think. It can pay you to insulate air lines to these machines and maintain high temperatures—and high air volume—right up to the end of the line. Temperature drop in uninsulated air lines to maintenance shops usually cools the air enough for hand-tool operation without the risk of personnel injury. Then you can combine the benefits of all three—inlet-air chilling, higher use temperatures and lower system maintenance through elimination of condensation—for greatest possible economic gains.

3—Compare dew-point temperatures

Intercooler			
Temperature, F	Pressure, psig	Dew point of air at 100 psig, F	Equivalent atm dew point, F
35	40	54	7
35	35	57	9
35	30	60	11
40	40	60	11
40	35	62	13
40	30	65	15
60	40	81	27
60	35	84	29
60	30	87	31
70	40	92	35
70	35	94	37
70	30	98	40
80	40	102	43
80	35	105	46
80	30	109	49
90	40	113	52
90	35	116	55
90	30	119	58
100	40	123	61
100	35	126	63
100	30	129	66

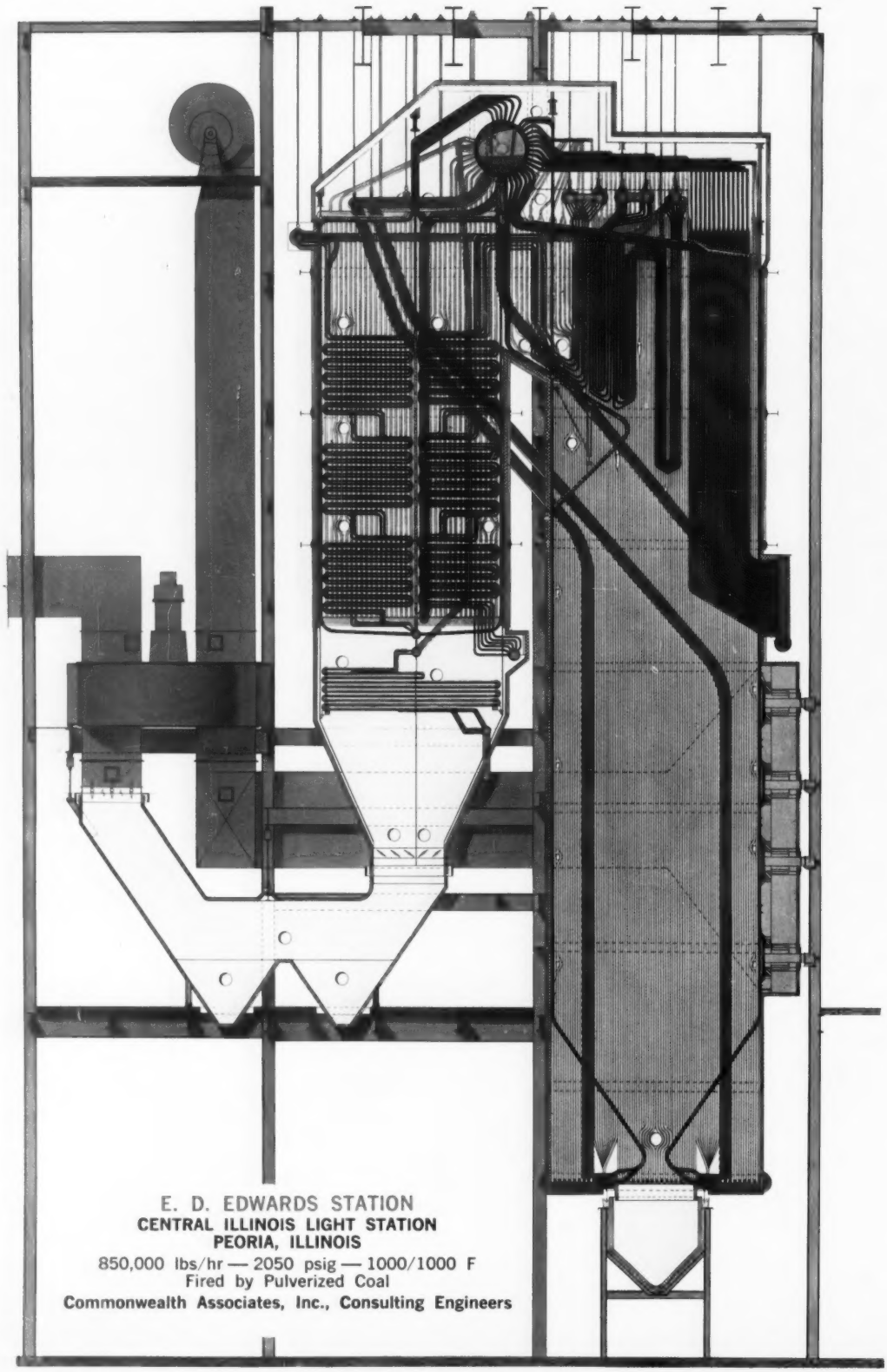
4—Check possible air-volume gains

Aftercooled			Inlet chilled			
Inlet temp, F	Use temp, F	Volume gain, %	Inlet temp, F	Use temp, F	Volume gain, %	Volume net gain, %
90	80	–2	40	190	30	32
80	80	0	40	190	30	30
70	80	2	40	190	30	28
60	70	2	40	190	30	28
50	70	4	40	190	30	26
40	70	6	40	190	30	24
30	70	8	30	190	32	24
20	70	10	20	190	34	24

For use temperature of 140 F subtract ten percentage points from net volume gains

Central Illinois Light Company has

850,000 lb/hr Boiler at



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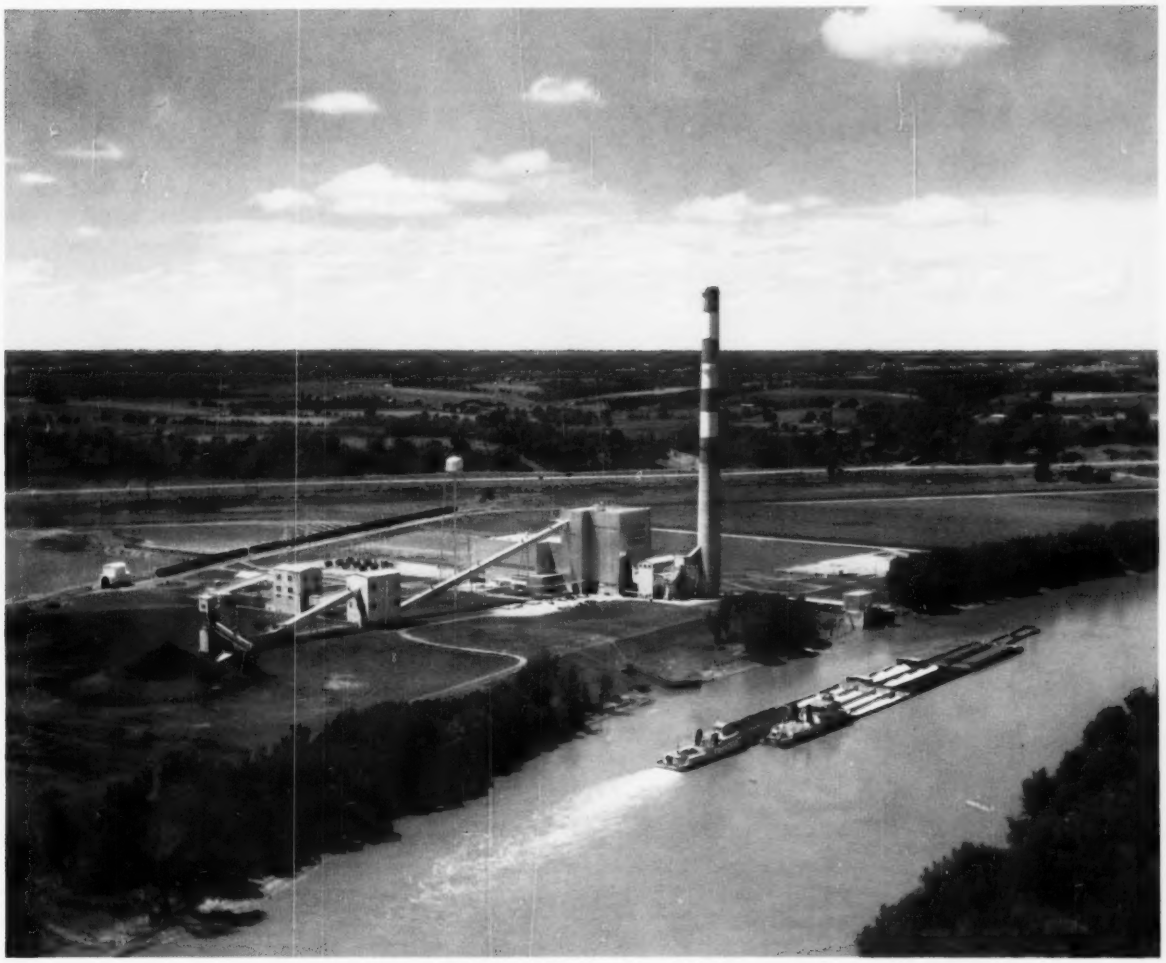

Central Illinois Light Company has purchased Riley Steam Generating Equipment since 1938. The latest, this 850,000 lb/hr reheat boiler, brings CILCO's total steam capacity with Riley boilers to 3,415,000 lb/hr. Six Riley boilers in operation at CILCO's R. S. Wallace Station at East Peoria, Illinois are continuing to provide dependable operation with records of high availability.

The new Riley boiler at the E. D. Edwards Station, which started operation in April, 1960, is living up to the reputation established by its predecessors.

Reheat steam temperature is controlled by gas flow dampers located below economizer; superheat is controlled by spray. Water tube platens in furnace add to furnace cooling and produce uniform furnace exit temperatures.

Central Illinois Light Company is one of many investor owned electric utilities that have repeatedly purchased Riley equipment. Today, many electric utility customers are installing Riley equipment because they recognize Riley's progressive design of boilers tailored to the requirements of the Electric Power Industry.

Investigate Riley's newest boiler designs. Call your local Riley representative or write RILEY STOKER CORPORATION, WORCESTER, MASSACHUSETTS.

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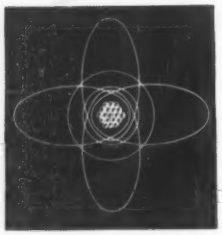


Nuclear notes

By B G A SKROTZKI, Associate Editor

England's Calder Hall has completed five years of operation with flying colors. On Oct 17, 1956, Her Majesty the Queen opened the world's first industrial-scale nuclear-power station. Since then, Calder's four reactors have fed over 3.7 mwhr of electricity into the national grid. Heat and electric output so far have topped design. Reactors and magnox-canned uranium fuel elements prove highly reliable: one reactor ran continuously for 12 months without a single shutdown caused by failure of any one of its 10,000 fuel elements. Load factors above 85% compare favorably with modern coal-fired stations (design load factor was set at 75% to allow continuous partial on-load refueling). These results were achieved despite extensive experimenting with the reactors.

PG&E is moving ahead with plans for its Bodega Bay Atomic Park; they've asked California Public Utilities Commission for a permit to build unit No. 1. Principal components of the unit will be a 325-mw turbine-generator and boiling-water reactor (POWER, Aug 1961, p 98). Site: the Sonoma County coast, 50 miles north of San Francisco.

Radioisotopes, versatile tools of modern technology, are currently used by 1900 U.S. industrial firms in ways ranging from medicinal tracer research to production-line thickness and density gaging. A radioisotope is a normally stable element, such as carbon, phosphorus or iron, which has been made radioactive in an atom-smasher. Here are some jobs now handled or under consideration for radioisotopes:

- Water-resource conservation uses radioisotopes to trace known water bodies, evaluate underground capacities of a lake or reservoir such as New Mexico's Lake McMillan.
- Radioisotopes help calibrate hydro turbines—in some cases, gold-198 detected previously unrecognized bearing wear that affected flow rating of the turbines.
- Air-pollution control gets a boost from portable SO_2 monitors using krypton-85.
- Atomic tracers are an old standby in underground pipelines, where they check for leaks, locate obstructions, mark interfaces between different flowing products.
- Radioisotopes will power a prototype saline-conversion unit now on the drawing boards.
- Exposure to radiation toughens plastic insulation on wire used in our space program.
- One line of research promising great things for the future is the perfection of diagnostic tests to find incipient disease—for example, gaging your tendency to arteriosclerosis by using radioisotopes to show how your body handles the food you eat.

SNAP-7C, a 10-w atomic generator to power an unmanned weather station buried in the Antarctic snows, is in the hands of the U.S. Navy and will be installed by early 1962. Design operating life of the Martin Co generator is two years. Four cylinders contain strontium-90 fuel pellets; thermocouples around the core convert heat of radioactive decay into electricity. This is a stronger version of the atomic generator now powering an automatic weather station above the Arctic Circle. Meanwhile, Dr Glenn T Seaborg, Chairman of the AEC, calls for faster development and testing of high-output compact reactors. Present schedule should produce a 30- to 60-kw SNAP-8 by 1965, but Seaborg, in a recent speech, demanded more powerful reactors—sooner.

Wanted: nuclear personnel to work in the AEC's expanded nuclear-safety activities. Nation-wide intensified recruitment is on, offering top salaries over $15,000 to nuclear engineers and physicists who will work out safety codes, inspect for compliance, evaluate hazards involved in proposed reactors. Qualified people are hard to come by because the relatively new field is growing so fast. Basic requirement is a BS in math, physics, ME or ChE, plus field experience. Interested? Get in touch with Div of Personnel, Code GFAJ, U.S. Atomic Energy Commission, Washington 25, D.C.

"Spring Action" gives you a leakproof seal with J-M SPIROTALLIC® GASKETS

Johns-Manville makes a specialty of building a lively "spring action" into Spirotallic Gaskets. Because of their superior resiliency, Spirotallic Gaskets can compensate for varying stresses and temperature changes ... follow minor flange separation ... and absorb vibration. Even under these difficult circumstances, they keep a tight, durable seal.

Examples of wide range of styles available

This quick adaptability has given Spirotallic Gaskets a tremendous popularity in the field. Their springiness is due to the special methods and control J-M uses in their manufacture. Spring-like metal strips, formed into a special vee shape, are alternately spiral-wound with an asbestos filler. The filler does the sealing . . . and the vee shape provides the "spring."

Another reason for the widespread acceptance of Spirotallic Gaskets is the fact that when the gasket has been compressed the proper amount, it reaches optimum performance for the bolting. Many different metals and fillers can be used. Each metal is color-coded to aid maintenance personnel in quick identification of the type of metal used.

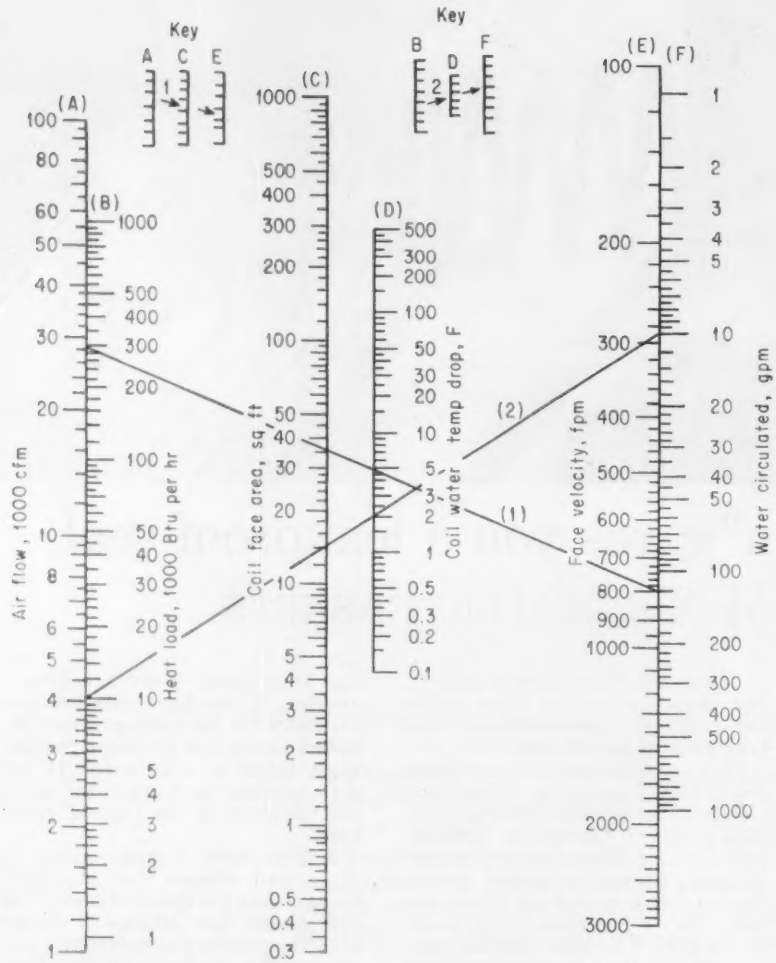
J-M produces a wide variety of sizes and shapes for standard flanges. And for special flanges, J-M will design and produce a gasket with the precise characteristics you require. For complete information, ask for J-M catalog PK-35A. Write to Johns-Manville, Box 359, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE

Power's data sheet

No. 352

Figure heating-coil face area and temperature drop



When choosing a heating coil for your air-conditioning or heating system, you need to know the face area to fix coil dimensions. This chart figures the coil's face area and helps find water-temperature drop in heating coils using hot water.

Example 1: Find face area for a heating coil handling 28,000 cfm of air flowing at 800 fpm over the coil face. To solve, enter the chart at scale *A* at 28,000 cfm and draw a straight line (1) to 800 fpm on scale *E*. At intersection with scale *C* read the answer, 35 sq ft.

Example 2: Find the water temperature drop in a hot-water heating coil with a load of 10,000 Btu per hr if the water flows at 10 gpm through the coil. Enter the chart on scale *B* at 10,000 Btu per hr and draw a straight line to 10 gpm on scale *F*. At intersection with scale *D* read temperature drop of 2 F.

Keys at top of chart show the related scales for easy identification. Two equations are plotted on this chart: $A = C/V$ and $T = H/500\,G$, where: A = coil's face area, sq ft; C = air flow through coil, cfm; V = coil face velocity, fpm; T = temperature drop of water flowing through coil, F; H = coil's heat load, Btu per hr; G = hot-water circulation rate through coil, gpm.

T G Hicks, *New York, N.Y.*

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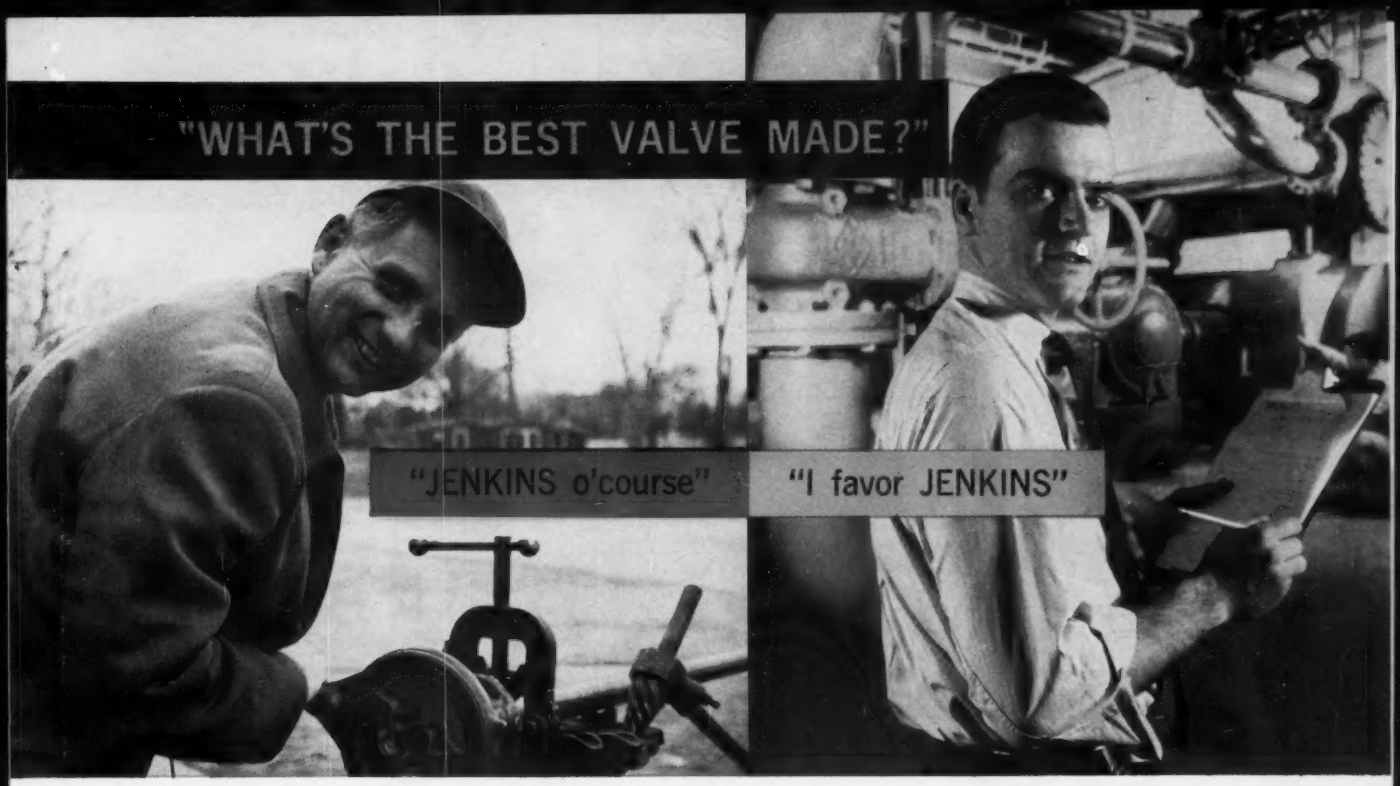
For more facts circle 252 on Reader Service card, p 117 ➤

"WHAT'S THE BEST VALVE MADE?"



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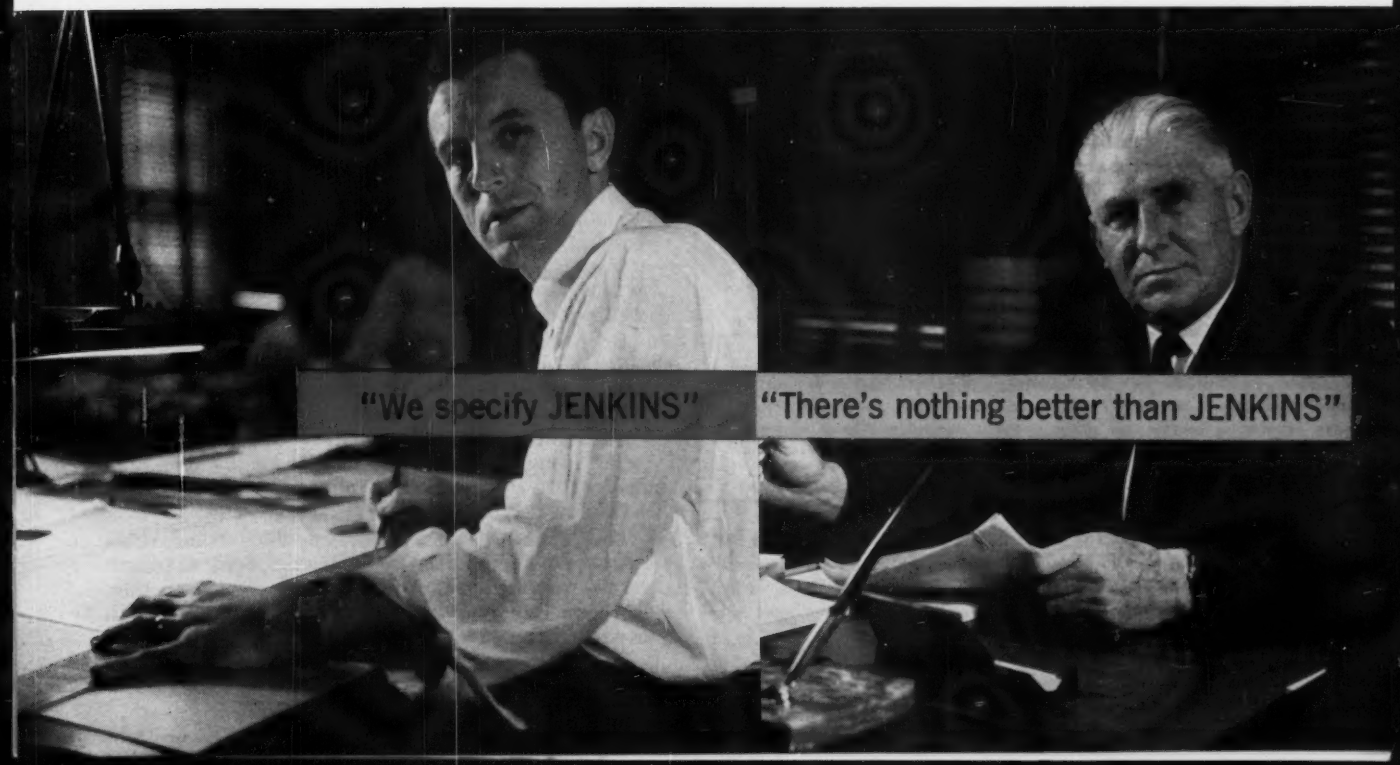

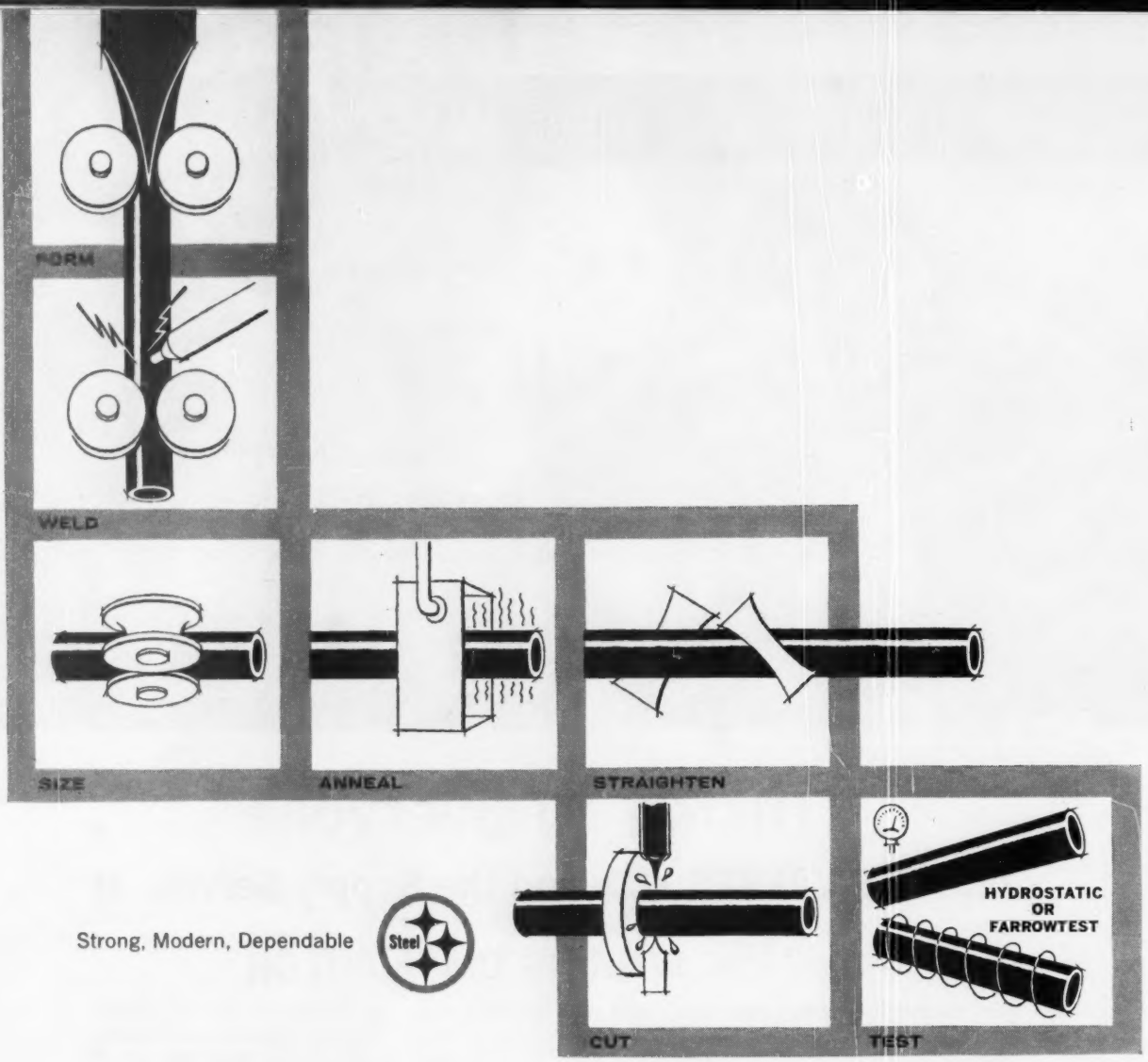

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Wall Thickness (B.W. Gage)	Minor Dimension of the Defect (Length or Depth)	Defective Area (Length, Depth Plane)
20	0.006"	0.0025 Square Inches
18	0.006"	0.003 Square Inches
16	12.5% of Wall	0.003 Square Inches
14 and 13	12.5% of Wall	0.004 Square Inches
12 and Heavier	12.5% of Wall	0.005 Square Inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.

FARROWTEST—QUALITY YOU CAN MEASURE. Not a laboratory theory, not a mere inspection tool, but an exclusive final production test that detects and rejects tubing containing defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with the table above at no extra cost.

With FARROWTEST, you are assured of boiler tubes pre-proved for high pressure applications. Less risk of hidden flaws which might develop during actual operations when other less positive tests are used.

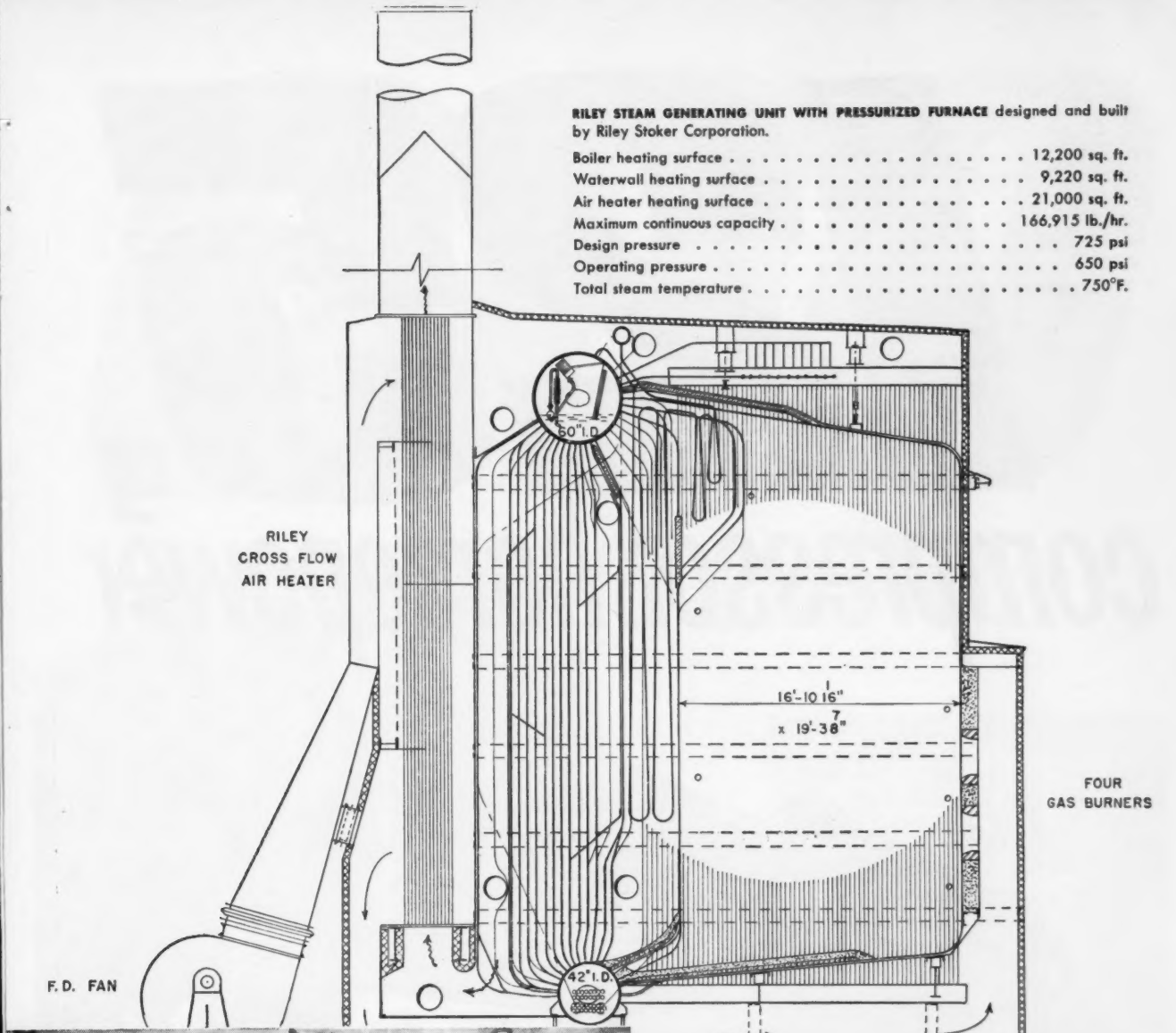
FARROWTEST probes the tube wall electronically, locating minute defects too small to be detected by ordinary pressure methods. And, most important, FARROWTEST is a *final* test, conducted *after* the stresses of mill processing.

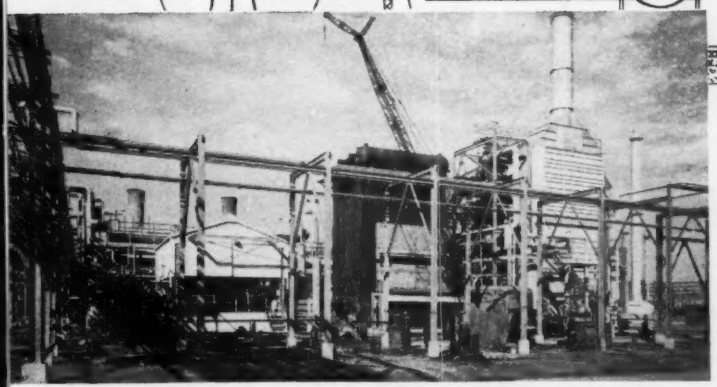
Republic offers FARROWTEST as an alternative to other less positive tests at no increase in cost. ELECTRUNITE Boiler Tubes are produced to meet ASTM specifications, ASME Boiler and Pressure Vessel Code, Federal and State committees, and boiler insurance requirements. These include non-destructive clauses permitting eddy-current testing —FARROWTEST.

The extreme conditions under which boiler tubes must serve demand the very finest. Specify ELECTRUNITE—exclusively FARROWTESTED for your protection. Call your Republic representative for full information or write direct.

RILEY STEAM GENERATING UNIT WITH PRESSURIZED FURNACE designed and built by Riley Stoker Corporation.

Boiler heating surface	12,200 sq. ft.
Waterwall heating surface	9,220 sq. ft.
Air heater heating surface	21,000 sq. ft.
Maximum continuous capacity	166,915 lb./hr.
Design pressure	725 psi
Operating pressure	650 psi
Total steam temperature	750°F.





Republic ELECTRUNITE Boiler Tubes were specified by Riley Stoker Corporation, Worcester, Mass., in constructing this 175,000 pounds per hour boiler for a major oil company. Uniform ductility of ELECTRUNITE assures trouble-free bending and stretching. Close tolerance tube thickness, roundness, and concentricity provide tight, accurate, long-lived installations.

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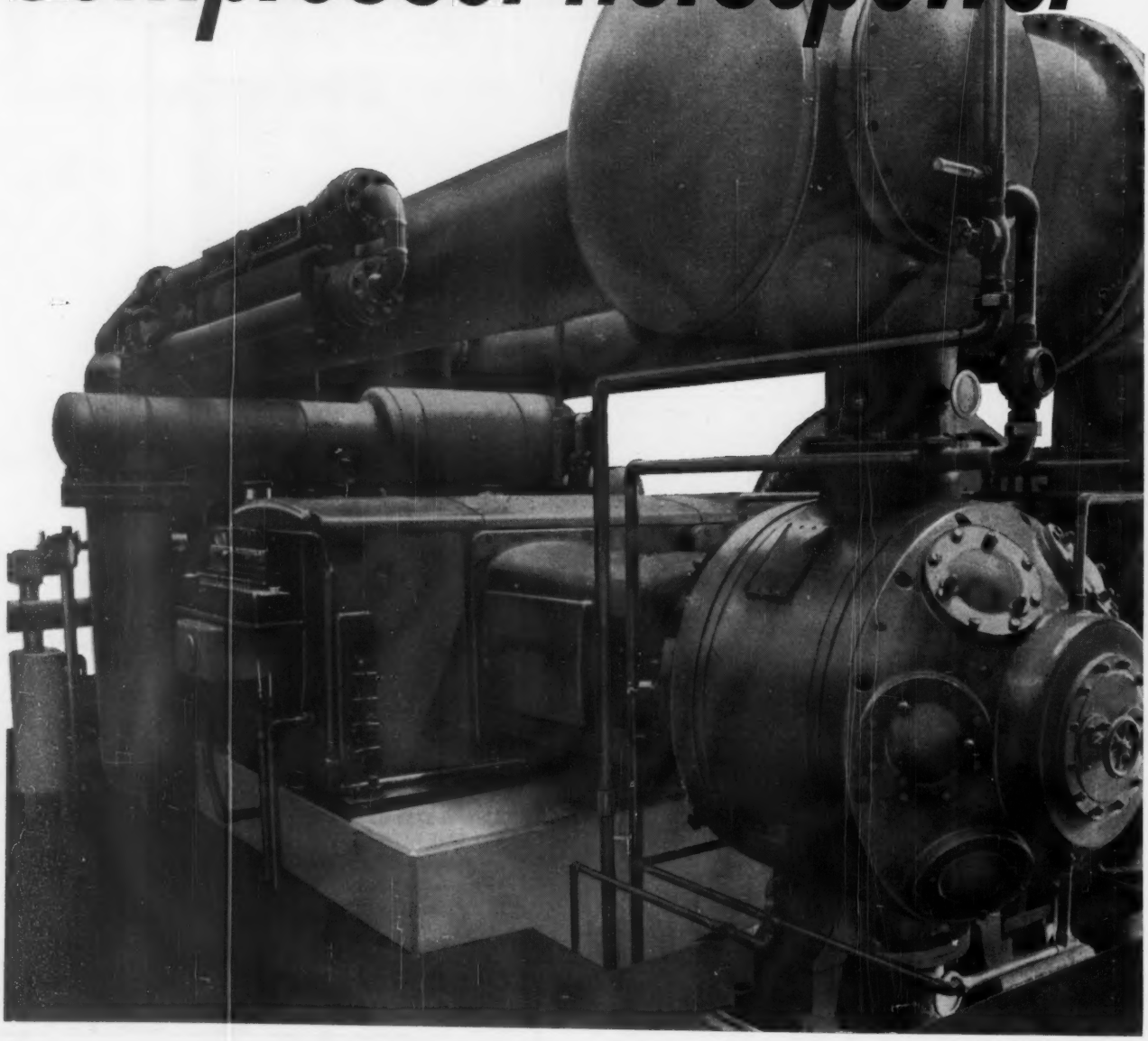
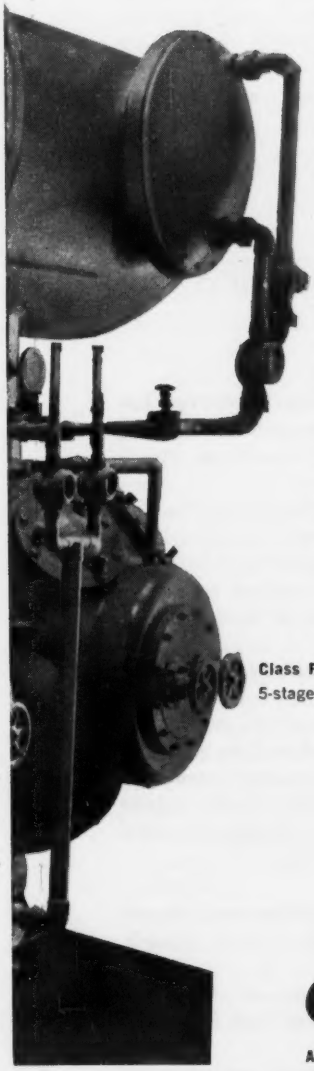
125, compressor horsepower



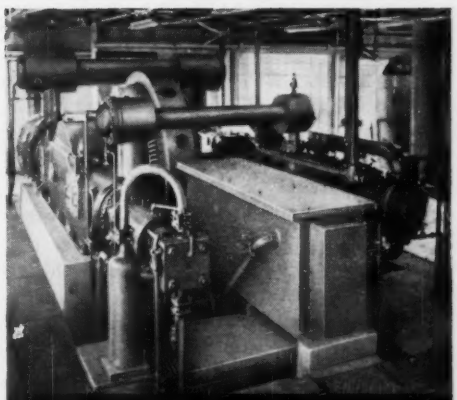
000 in cryogenic service



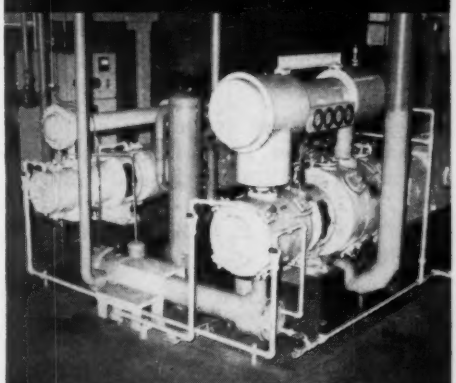
Class FE-55 horizontal, balanced-opposed, 5-stage compressor in steel mill service.

More than 125,000 compressor horsepower in cryogenic service . . . proof of Chicago Pneumatic's ability to meet the stringent service demands of the process industries. In the field of low-temperature liquid and gas processing, CP Compressors have earned an enviable reputation for outstanding dependability and long life.

The CP line features several basic compressor types, available in horsepowers to 6,000 and pressures to 15,000 psig., motor or steam driven. For full details, write: *Chicago Pneumatic Tool Co., 8 East 44th St., New York 17, N. Y.*



Class HCE-5 horizontal duplex, four-corner 5-stage, compressor operating at 3,000 psig.



Class OCE-4 horizontal duplex, 4-stage machine in an oxygen plant.

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Technical briefs . . . A world-wide look at

To find out how to get more information on any of these papers, see box on p 114

Superheater-alloy test results—hot topic at this year's National Power Conference

Scaling behavior of superheater-tube alloys in ASME high-temperature-steam-research tests at 1100-1500 F, *F Eberle and C H Anderson, The Babcock & Wilcox Company*

Adverse scaling effects prompted this test program: (1) Scaling causes significant reduction in tube-wall thickness, overstressing and premature failure. (2) Flaking, cracking or exfoliating scale may accumulate and plug loops or bends. (3) Some tightly adhering scales can insulate the tubes, impair heat-transfer rates.

Tests at 1200, 1350 and 1500 F ran up through 18 months; results are presented in tables and photos. Scale behavior was evaluated in four ways: (1) Scale was visually examined in the test racks to determine uniformity, adherence or tendency to crack, spall or exfoliate, especially in areas affected by air blowing. (2) Thickness, uniformity and structure of the scale formed was determined by metallography. (3) Analysis was run on exfoliated scale found in the bottom sections of test tubes in the rack. (4) Steam-side scale formed in the tubing with longest exposures was also analyzed. All four examination methods are detailed.

These are two of the conclusions reached from the tests: (1) All ferritic and austenitic steels (with exception of TP 310, Incoloy and Inconel) showed a tendency toward flaking and exfoliating scales, and this tendency increased with temperature and time of exposure. (2) Ferritic steels formed heavier scales than the austenitics at their respective exposure temperatures. *ASME 61-PWR-3*

Metallurgical evaluation of superheater-tube alloys after 12 and 18 months' exposure to steam at 1200, 1350 and 1500 F, *C L Clark, The Timkin Roller Bearing Co, J J B Rutherford, The Babcock & Wilcox Co, A B Wilder, United States Steel Corp and M A Cordovi, The International Nickel Co*

Detailed test results after exposure for 18 months at these high temperatures are presented in graphical form. Results cover tensile properties, hardness, impact resistance, flattening tests, microstructure, bulging and failures. List of alloys tested: TP-304, TP-316, TP-321, TP-347, TP-310, 16-25-6, 17-14 Cu-Mo, 15-15 N, Inconel and Incoloy.

Some conclusions: No failures occurred at 1200 or 1350 F for the 18-month period. All except TP-316 and 15-15 N tubes failed at 1500 F. Causes were actual rupture, bulging and in one case excessive localized oxidation. (3) The only mechanical properties appreciably affected by exposure were ductility and impact resistance. Greatest changes here occurred during the first six months of exposure. *ASME 61-PWR-4*

The effect of corrosion by steam at 1100-1500 F upon the heat transfer through superheater-tube alloys, *H L Solberg, J E Brock, W J Rebello, Purdue University*

Test method to determine heat-transfer changes produced by corrosion used a closed-loop Dowtherm circuit for heat dissipation and electrically superheated steam as heat source. Test racks for ferritic steels operated at 1100 and 1200 F while those for austenitic steels ran up to 1500 F. Results are tabulated.

Two conclusions: All austenitic alloys showed *better* heat transfer after exposure to steam than when clean—increased roughness of inner surface caused this phenomenon. So for conditions covered by these tests, high-temperature steam has no adverse effect on heat transfer through austenitic steels. Heat-transfer rates for ferritic steels did drop significantly, depending on analysis. *ASME 61-PWR-1*

Nuclear-power facilities

Hallam Nuclear-Power Facility, prototype for advanced sodium-cooled power stations, *R W Dickinson, R C Gerber, C L Larson, North American Aviation, Inc*

The 75-mwe unit at Hallam Nuclear-Power Facility is scheduled to run at full power by July 1962. Reactor has a nominal full-power rating of 240 mwt. This is the calculated power required to give a steam flow of 710,000 lb per hr at throttle conditions of 800 psig, 825 F.

A complete description of this sodium-cooled graphite-moderated nuclear-reactor concept points up two important characteristics: (1) high heat-transfer characteristics of liquid sodium and (2) inherent safety of a low-pressure reactor system. Approximate cost of the Hallam nuclear facility is $450 per net kwe (but turbine-generator is included in the conventional plant). *AIEE 61-988*

The ESADA Vallecitos experimental superheat reactor, *John Barnard, General Electric Company*

Empire State Atomic Development Associates (ESADA), an association of New York State util-

ity companies, has started to design and build an experimental superheat reactor at the Vallecitos Atomic Laboratory. To simplify initial operation of the experimental unit, a gas-fired boiler will provide cooling steam at 1000 psig and saturated conditions. Power level at first will go up to 12.5 mwt.

Later, the existing Vallecitos boiling-water reactor will supply steam. Then these two reactors will operate in series and supply valuable data toward the design of a large nuclear-power plant. ESADA operation calls for the 12.5 mwt at 905 psig, 810 F. Reactor will go critical in fall, 1962.

Several drawings supplement construction details for the superheat reactor. *AIEE 61-983*

Hydro-power design

Surges in air vents adjacent to emergency gates, *I W McCaig, F H Jonker, H G Acres & Co, Canada*
Air-vent allowance in gravity-flow hydraulic conduits is based on two considerations: (1) a sudden increase in conduit discharge and (2) intake-gate closure against a steady discharge. Drawdown in an intake-gate air vent following gate closure and against a constant discharge is examined in detail. Under these conditions a backsurge is likely to occur, and if it's not properly provided for, can seriously damage the intake gate and its hoisting mechanism.

Formulas are developed to illustrate mechanics of the surge following intake-gate closure, to determine minimum surge level in the air vent and maximum elevation reached by backsurge. In one case vent level rose some 80 ft above reservoir surface. This exerts considerable load on intake gate in the reverse direction, which must be figured in gate design. *ASME 61-HYD-2*

High-head Francis turbines for Mammoth Pool, *Luther Brown, Allis-Chalmers Mfg Co*
The Mammoth Pool turbines—88,000 hp at 360 rpm under 950-ft head—are largest high-head Francis units in the U.S. Decision to use Francis instead of the more usual impulse design for this head was based on higher generator speed, increased head possible—plus annual savings of $12,000 to $15,000 depending upon mode of operation. And construction-cost savings were approximated at $600,000.

Many design and operating features of this unique installation are detailed. Among them: seal location to control lift and thrust (2) motoring with tailwater depressed and full pressure on wicket gates (this cuts power to 0.88 mw—a saving of 2.77 mw over submerged motoring) (3) pressure-regulator design and operation (4) inlet butterfly-valve requirements, mechanical and hydraulic. *ASME 61-HYD-21*

Design of high-head penstocks, *W J Smith, Montreal Engineering Company Ltd, Canada*
Two recent projects—one in Canada and the other in India—give an excellent comparison between penstock designs for Francis and impulse turbine installations. Heads at the Indian project run up to 2470 ft; at the Canadian installation (Spray Hydro-Electric Project) they hit 900 ft.

Penstock materials are reviewed in the light of today's availability. Stresses resulting from water hammer are a vital part of the study. Result, according to the author: it is evident that certain high-tensile steels have a definite place in high-head-penstock installations. *EIC 61-EIC-10*

Electric technology

Auxiliary drives and factors affecting their selection, *J J Heagerty, General Electric Company*
Total hp required by major auxiliaries in steam-electric-generating stations continues to increase as a percentage of gross station output, and gains in once-through boilers aggravate the increase. So auxiliary-drive arrangements get more detailed attention and many alternate schemes are considered during design stages.

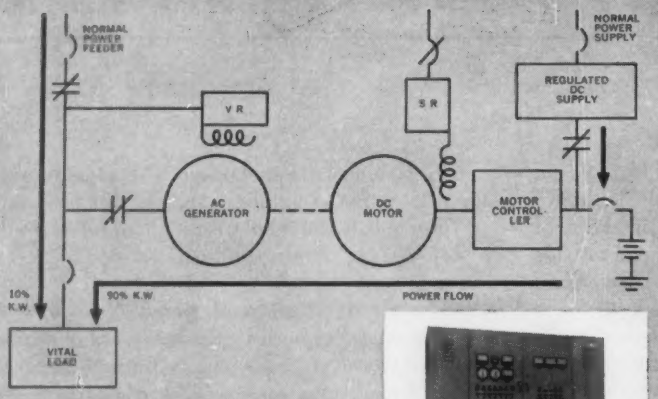
Two design criteria for electric auxiliary-drive systems: interrupting duty for the switchgear, voltage dip on starting the largest motor and on bus transfer. To get an idea of motor sizes involved here: For a 400-mw unit at 2000 psig, auxiliary kva total about 27,000; the boiler-feed pump needs about 11,000 hp. Compare this to an 800-mw unit with a once-through steam generator for a throttle pressure of 3500 psig. Here auxiliary kva is up to about 70,000 and total boiler-feed-pump hp jumps to 40,000.

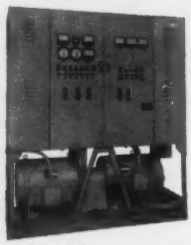
Motor drive arrangements for feed pumps, fans and other major auxiliaries are detailed. These include factors in motor selection—insulation class, enclosures. Alternate boiler-feed-pump drives discussed include generator shaft and mechanical-drive turbines.

Size and number of drives per given unit size is changing in line with the trend toward unit simplification and reduction in number of components. But these changes have a definite tie-in with probabilities of outage and availability, as several examples show. *AIEE 61-989*

continued

AN AMMONIA PLANT APPLICATION...





In the installation pictured, the rating of the AC generator is 12 KW, .8 power factor, 1 phase, 60 cycle, 460 volt.

ANOTHER EXAMPLE OF HOW KEARFOTT ASSURES CONTINUOUS, UNVARYING POWER FOR CONTROL EQUIPMENT AND INSTRUMENTATION

The heavy losses which can occur when power interruptions or fluctuations affect the control equipment and instrumentation in manufacturing processes, are effectively prevented by Kearfott Uninterrupted Power Systems. The system described below, used in an ammonia plant, is typical of many now in use, all with a perfect record for reliability.

In this particular system, a DC motor drives an AC generator, the output of which is the same as the normal available power. Meanwhile, the DC power that runs the motor also keeps the batteries in fully charged condition. When failure of the prime power occurs, the motor continues to run on the batteries, and the AC generator continues to meet the vital power load requirement. Controls and instrumentation continue without interruption. Voltage and frequency are regulated to within ±1% of rated values, regardless of variations in normal power supply input.

Kearfott's compact uninterrupted power equipment combinations are also available in 2 and 3 unit systems operating in parallel with or isolated from the line. Provisions may be had for audible and/or visual alarms to indicate over- and under-voltage, overload or ground conditions.

Generator ratings to 150 KVA 60 and 400 cycles, single and polyphase. Frequency, voltage and transfer regulations as required by the application.

Write for complete data

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GENERAL PRECISION, INC.

Little Falls, New Jersey

For more facts circle 255 on Reader Service card, p 117

Technical briefs

Begins on page 108

Industrial-control application in steam - electric - generating stations, *M P Smull, Southern Services Inc*

Through its operating subsidiaries, Southern Services applies many items of low-voltage industrial switchgear and control equipment. In each case, these are their design objectives: (1) maximum personnel safety (2) maximum reliability consistent with economy (3) maintenance convenience.

Experience with this equipment across a broad front has led them to specify certain features, some not normally found in standard industrial designs. Example: today's standard 600-v breaker design mounts four 15,000- or 25,000-amp breakers vertically. But Southern Services uses only three compartments for breakers; the fourth is reserved for terminal-control wiring. In fact, their specifications require that control wiring be run to this vacant fourth compartment, at either top or bottom depending on station design.

Other 600-v-switchgear modifications involve such things as barriers, compartment width and manual operation of breakers. In addition, special features for contactors and molded-case breakers are covered. *AIEE CP-61-1107*

Proposed new breaker ratings and their effect on application for industrial systems, *A H Knable, Allis-Chalmers Mfg Co*

New symmetrical ratings for circuit breakers are presented, followed by the approach for determining fault currents. Author specially mentions proposed k curves for momentary limitation. These small-letter k curves should not be confused with the large K, which stands for voltage-range factor.

Four steps in applying circuit breakers are followed by a sample calculation. Appendixes cover such topics as: (1) error introduced by not adding ac and dc components separately (2) development of k curves (3) X"d vs X'd for motor representation. *AIEE 61-1033*

OTS papers

Office of Technical Services, U.S.

Taming a Nuclear Reactor

. . . where gaskets must not fail

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Published reports* detail the development of the right Flexitallic Spiral-Wound Gasket for the Experimental Boiling Water Reactor at the Argonne National Laboratory. Difficulties surmounted included service at elevated temperatures and pressures, large closure requirements, corrosion resistance and interpretation of irradiation effects.

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Corrosive fluids can be sealed at temperatures from extreme sub-zero to maximum temperatures compatible with available metals. Pressures ranging to 15,000 lbs. p.s.i. or temperatures to 2500°F. do not impose impossible limitations.

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Technical briefs

Begins on page 108

Dept of Commerce, announces availability of the following publications:

Radioactive waste disposal, prepared by McLain Rodger Assoc for Argonne National Laboratory, Sept 1960, 169 pp, ANL-6233, $2.75

A thermal problem associated with underground storage of radioactive wastes, Union Carbide Corp for AEC, 72 pp, ORNL-3002, $2.00

Radioactive-waste processing and disposal, a literature speech prepared by T F Davis, June 1960, 92 pp, TID-3555, $2.25

Air pollution and purification, a bibliography listing 124 U.S. and foreign research reports, SB-448, 10¢

An evaluation of fossil superheat for nuclear-power plants, prepared by Ebasco Services Inc, Oct 1960, 297 pp, NYO-9400, $3.50

Reactor-development-program progress report, Dec 1960, Jan 1961, 68 pp, ANL-6295, $1.75

Heavy-water-moderated power reactors progress report, Nov 1960, 40 pp, DP-565, $1.00

Fuel cells and related research, a bibliography listing 80 reports from the armed services and AEC and foreign sources, SB-447, 10¢

Second status report on fuel cells, B R Stein and E M Cohn, Dept of the Army, Dec 1960, 80 pp, PB-171-155, 75¢

Economics of nuclear power, a bibliography by W E Bost, AEC, Jan 1960, 82 pp, TID-3089, $2.00

Nuclear-energy power sources, Feb 1961, 12 pp, TID-6612, 50¢

Prototype and full-scale power-plants gas-cooled reactor project, Progress report No. 4, Sept 1960, 117 pp, AEPSC-632, $2.50

Gas-cooled reactors in the U.S.A., Nov 1960, 53 pp, ANL-6255, $1.25

Heavy-water-moderated power reactors, engineering and economic evaluation, Vol II, Dec 1960, 198 pp, DP-520 $3.00

Heavy-water-moderated power reactors progress report, Jan-Mar 1961, 47 pp, DP-585, $1.25

Transient hydrodynamic operation of EGCR main-coolant system, Mar 1961, 29 pp, K-1468 (Pt 1), 75¢

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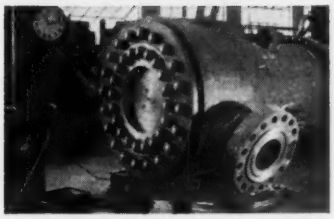
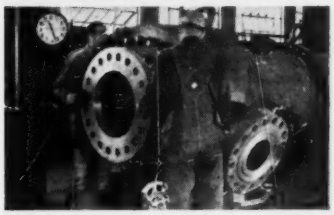
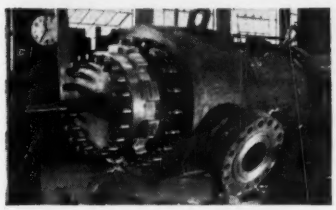
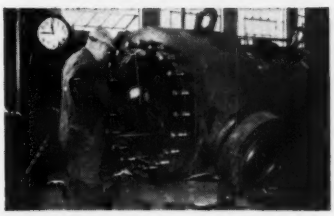
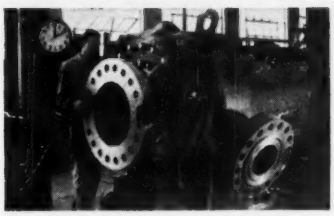
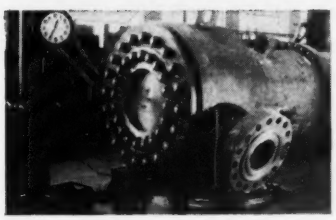




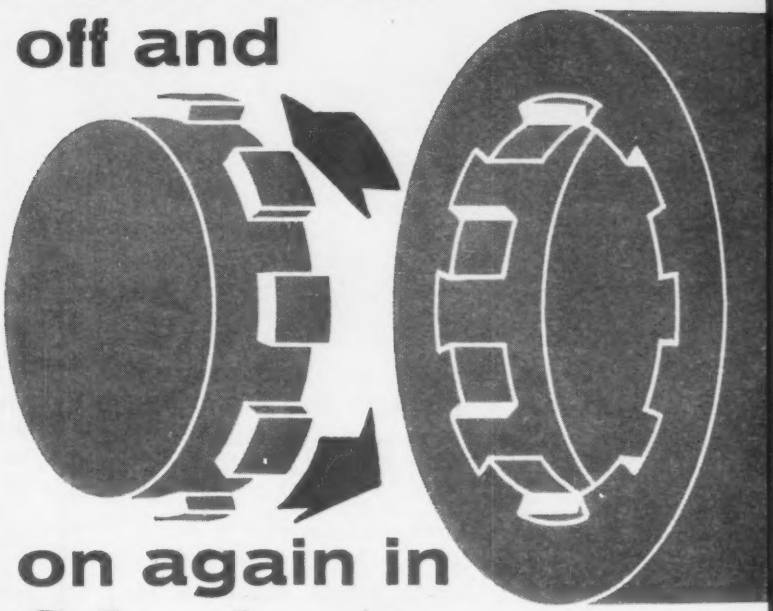








head cover off and



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When the cover is removed the entire tube sheet and all tube joints are readily accessible for examination and cleaning from outside the heater. No need to squeeze and squirm inside the water head whether heaters are large or small.

G-R Type "L" breech block high pressure heaters are available with all welded seals without gaskets, with rolled or rolled-and-welded tube joints.

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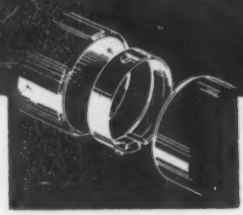

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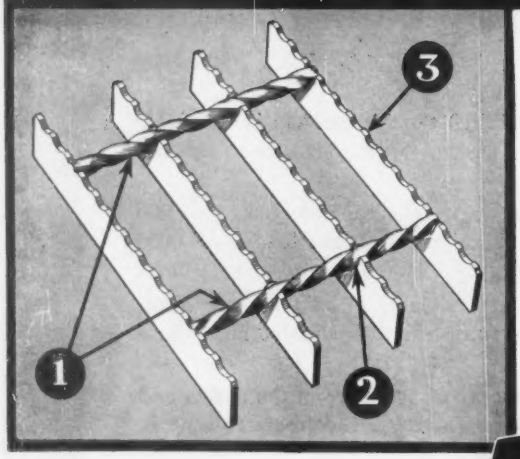

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Technical briefs

Begins on page 108

Operation and analysis of a 3000 - kw liquid - metal model steam generator, Feb 1961, 211 pp, NAA-SR-4884, $3.00

Effect of heat flux on the corrosion of aluminum by water, Part II, 40 pp, ORNL-3056, $1.00

Study of conventional steam-power-plants capital and energy costs, 44,000 and 12,500 kw (gross), Feb 1961, 81 pp, TID-8532, $2.00

Study of nuclear-power-plants capital and power - generation costs, 44 and 12.65 mwe (gross), Feb 1961, 189 pp, TID-8533, $2.75

Study of conventional process-steam-plants capital and steam-production costs, 125,000 lb per hr (40 mwt), Feb 1961, 37 pp, TID-8534, $1.00

Experimental organic-cooled reactor, conceptual design, W E Nyer, J H Rainwater, Phillips Petroleum Co for AEC, 242 pp, IDO-16570, $2.50

Controlled thermonuclear reactions — a selective bibliography, S F Lanier et al, AEC, Jan 1961, 184 pp, TID-3072 (Rev 1), $2.75

Direct - energy - conversion devices—a literature search, H D Raleigh, AEC, Mar 1961, 23 pp, TID-3561, 50¢

To obtain complete text

Material for these abstracts comes from the following sources. Order complete paper from source, *not* POWER.

ASME: American Society of Mechanical Engineers, United Engineering Center, 345 E 47th St, New York 17, N.Y. Members, 50¢; nonmembers, $1.00.

EIC: Engineering Institute of Canada, 2050 Mansfield St, Montreal 2, Quebec, Canada. 50¢.

AIEE: American Institute of Electrical Engineers, United Engineering Center, 345 E 47th St, New York 17, N.Y. Members, 50¢; nonmembers, $1.00.

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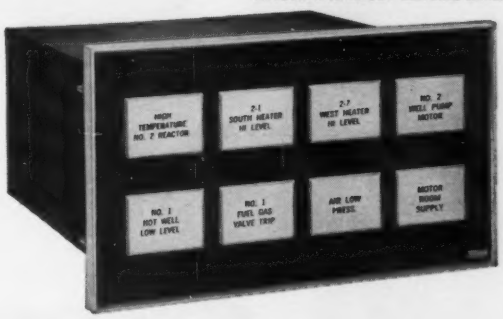
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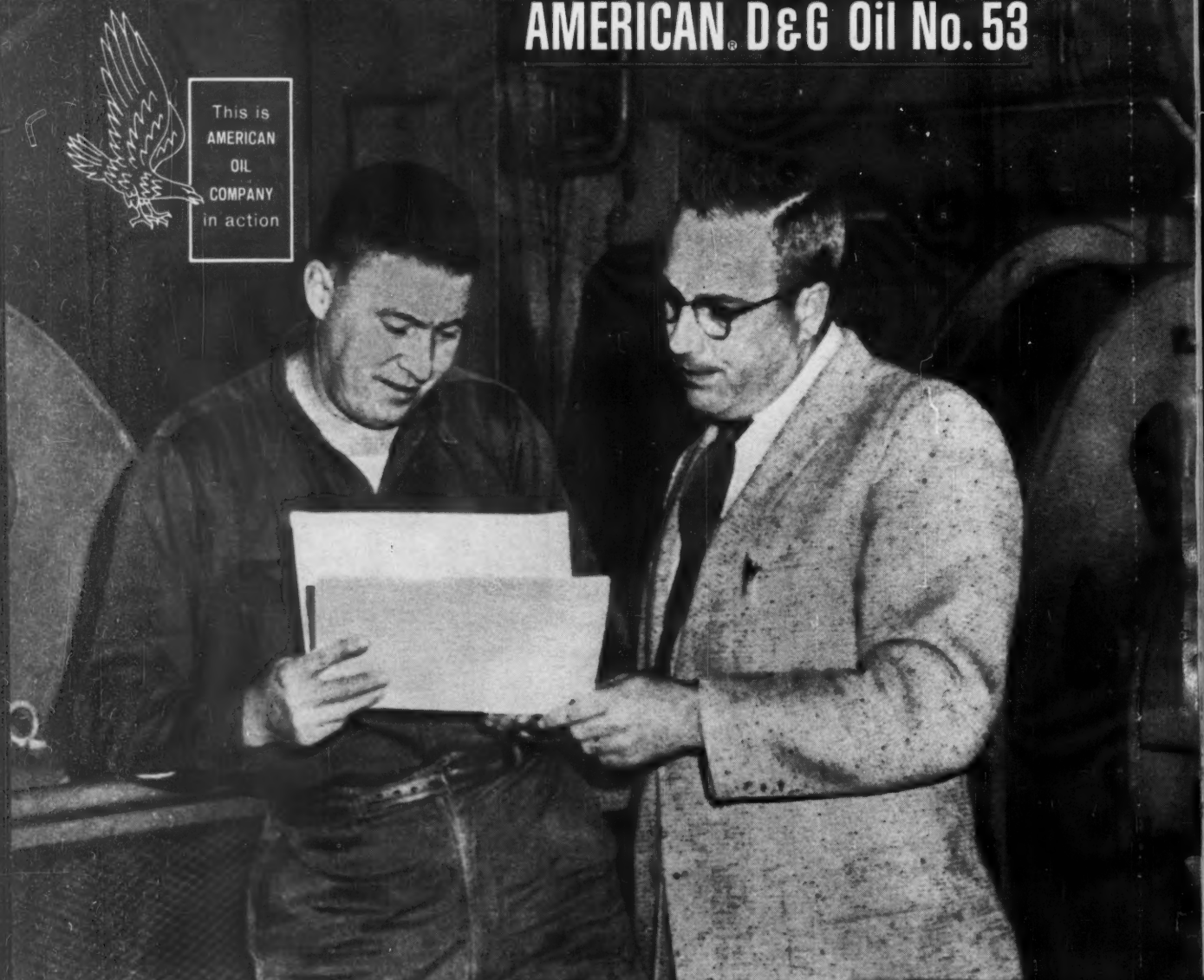

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New free literature

Air-conditioning systems

101 **Infrared-heater** 16-p application manual PE-2-61 describes ways to control body heat loss and calculate heating requirements. Panelbloc Div, The Bettcher Manufacturing Corp

102 **Gas-fired unit heaters** are subject of data sheets 2760-3 and -4. Dimensions and ratings are tabulated. Young Radiator Company

103 **Self-contained heater** for comfort and industrial process heating and ventilating is topic of 8-p booklet. Tabulates ratings, operating and performance data. Todd Shipyards Corporation

104 **Direct-fired gas heaters** are covered in 8-p handbook GN-200. Applications: space heating, makeup-air tempering and combination heating-cooling systems. Reznor Manufacturing Company

105 **Fans** operate at lower speeds, use less hp. 12-p bulletin ASQ-102 contains mechanical efficiency diagrams, selection tables for each of seven sizes—8¾ to 18¼ in. Chicago Blower Corporation

106 **Fans** are topic of 44-p bulletin A-1203. Discusses construction, available drive arrangements, configurations and drive types. Capacity tables are included for 12 sizes, each in single- and double-inlet, single- and double-width designs. American-Standard Industrial Div

107 **Air-pollution-control** equipment collects dusts in metalworking, woodworking; outlined in 4-p folder 230. Self-contained cyclone separators and fabric filters in low-volume systems are detailed. John Wood Company, Air Pollution Control Div

108 **Steam and hot-water heaters** are topic of 20-p catalog. Unit capacities range from 13,400 to 1,062,000 Btu per hr; designs feature horizontal, vertical and 4-way air-discharge patterns. Carrier Air Conditioning Company

109 **Membrane filter** for air-sampling and ultrasonic cleaning is topic of 24-p booklet. Accessories, prices, filter-characteristics comparison and compatibility tables are shown. Gelman Instrument Company

Steam and hot-water systems

110 **Combustion control** for boiler fired with a combination of waste bark and coal is discussed in case history found in 12-p bulletin 1078. Blaw-Knox Company, Copes-Vulcan Div

111 **Abrasion resistance** of refractory brick and monoliths was tested using impingement of a stream

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of air-entrained silicon carbide grit. Results on refractories before and after heat treatment are shown in 8-p reprint. Harbison-Walker Refractories Company

• **Heating**

112 **Fuel-oil heaters**—their dimensions, sizes, capacities—are given in 12-p illustrated bulletin 1416 from The Griscom-Russell Co

113 **"Fluidized beds"** is title of revised 4-p publication GED-4306A. Applications: annealing, normalizing, solutionizing, aging and hardening. General Electric Co

• **Boilers**

114 **Packaged hot-water boiler** is designed for forced-circulation heating systems. Bulletin 1265 is from Orr & Sembower, Inc

115 **Boiler** for up to 250,000-lb-per-hr capacities is feature of 6-p booklet. Unit is suitable for pressurized or induced-draft firing. Combustion Engineering, Inc

• **Fuel handling**

116 **Wire-rope conveyors** for above- or underground service are topic of 26-p brochure 173. Chapters: head and tail ends, power units, belt takeups. Hewitt-Robins

117 **"Conveyor belt engineering"** is title of 24-p bulletin 175. Chapters give info you need to calculate hp, determine speed, idler and drive factors, hp required to overcome pulley friction and estimated average belt weights. A typical conveyor problem is diagramed. Hewitt-Robins

Fluid-handling systems

• **Water treatment**

118 **"Descaling power boilers** chemically" is title of 4-p folder 40-B. Outlines descaling with safety precautions. Oakite Products, Inc

119 **Filters**—vertical, backflow and horizontal pressure and tubular—are topics of data sheets 112, 114, 122 and 123 respectively. Industrial Filter & Pump Mfg Co

120 **Boiler-blowdown systems** 4-p catalog discusses water impurity problems. Sentry Equipment Corp

121 **Filter** removes iron and manganese, can be used for other water-clarification duties. Bulletin is offered by Hungerford & Terry, Inc

122 **Cation-exchange-resin** case histories are given in 4-p report. Examples: softening, deionization. Rohm & Haas Company

123 **Sewage-treatment plants** are illustrated in 12-p bulletin 7330. Design, operation and installation are chapters. Dorr-Oliver Inc

continued

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NEW FREE LITERATURE continued.....circle key numbers, page 117, for your copies

124 **Thin-film process** distills salt and brackish waters. 8-p bulletin GED-4135 indicates its potential in the industrial, municipal and marine fields. General Electric Company

• Water treatment instrumentation and controls

125 **Boiler-blowdown controls,** heat-recovery systems and metering pumps and chemical-feeding systems are outlined in 4-p folder which refers you to other bulletins for more details. The Madden Corporation

126 **Residual-chlorine analyzer** for water supplies and sewage effluents and a null-balance potentiometer are described in 6-p catalog 17B2200. Fischer & Porter Company

127 **Electrolytic-conductivity cell** is described with mounting data in 6-p booklet NS6(1). Tables aid selection of proper teflon or Penton plastic cell. Leeds & Northrup Company

128 **Silica analysis** report D-61-2 tells why an eastern generating station switched from manual to automatic analysis in feedwater and makeup. Milton Roy Co

• Pumps

129 **Centrifugal pump's** piping connections don't have to be broken while servicing. Selection tables are given in 12-p catalog HY-558-A. Bell & Gossett Company

130 **Reciprocating,** rotary- and centrifugal-pump fundamentals — characteristics, operation and selection—are outlined in 16-p nontechnical booklet. Goulds Pumps, Inc

131 **Centrifugal pump** covers 5- to 775-gpm, 10- to 300-ft tdh range for chemical processes. 16-p revised brochure 725.1 features interchangeability charts and diagrams. Goulds Pumps, Inc

132 **Close-coupled** end-suction pumps take to cooling tower, air-conditioning, boiler-feed and condenser-circulation applications. Capacities range up to 1600 gpm, heads to 330 ft and temperatures to 250 F. 8-p circular 108 is from Aurora Pump Div, The New York Air Brake Company

133 **Split-case centrifugal pumps** in capacities to 6000 gpm and heads to 380 ft are subject of 8-p bulletin 105C. Aurora Pump Div, The New York Air Brake Company

134 **Close-coupled pump** handles noncorrosive liquids up to 180 F. Leaflet 52B1010 is from Allis-Chalmers Manufacturing Co

135 **Ac pump-motor** line is announced in 6-p folder L-4121A. Two groups are featured: jet pump from ¼ to 2 hp; close-coupled to 10 hp. Kingston-Conley, Inc

136 **Mechanical-seal** 8-p manual M 101-7 outlines replacement for maker's end-mounted sealed and packed pumps. Roy E Roth Co, Turbine Pump Div

137 **Centrifugal pumps** for corrosive solutions — from a — aluminum

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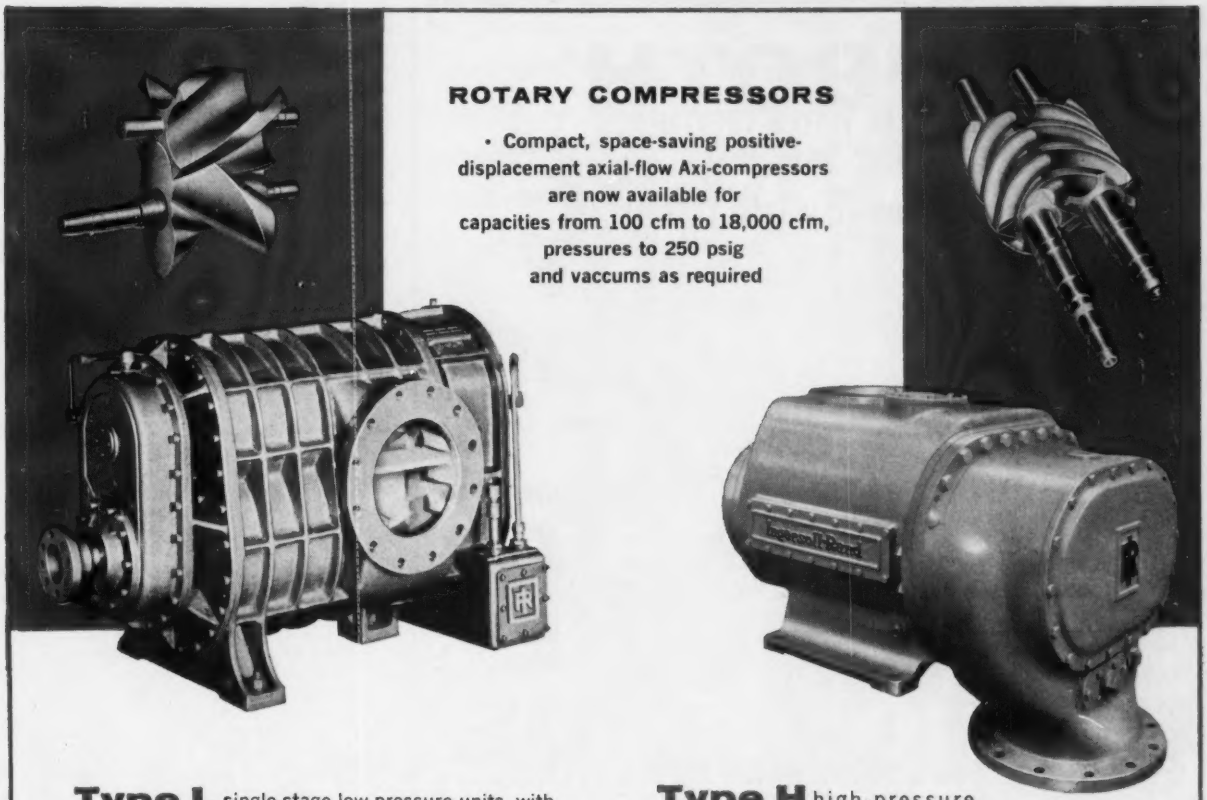

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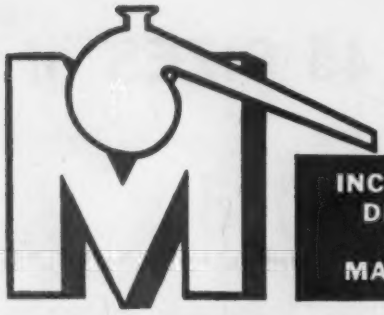

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Free literature

Begins on page 117A

chloride—to z—zinc sulfate—are described in 8-p brochure 301. Industrial Filter & Pump Mfg Company

138 **"When you buy your pump"** is title of guide to pump selection for water supply or booster service. Checklist compares submersibles. Sumo Pumps, Inc

139 **Centrifugal-pump** installation, servicing and maintenance are topics of 18-p bulletin G-2971. Chapters: storage, alignment, pumping, lubrication and trouble-shooting. Worthington Corporation

140 **Pumping motors** rated 100 to 2750 hp, part of Detroit's water and sewage systems, are discussed in 6-p booklet 10-A. Ideal Electric and Manufacturing Co

141 **Oil-lubricated pump-motors** in frame sizes 254 to 445 UP are covered in 28-p instruction manual. Divided into installation, operation, maintenance and repair sections, book gives trouble-shooting chart for when motor fails to start or come up to speed, runs hot or vibrates. U. S. Electrical Motors Inc

142 **Centrifugal pumps** in capacities to 3000 gpm and heads to 550 ft at 1750 rpm are detailed in 8-p booklet 722.6. Included: performance curves, interchangeability charts. Goulds Pumps, Inc

143 **Fluid drive** for main-turbine shaft drive of boiler-feedwater pumps is topic of 12-p catalog A-919. Basic dimensional info, cross sections and data on how drive works are found in bulletin offered by American-Standard Industrial Div

144 **Pumps,** rated to 600 gpm, handle problem liquids — they flow through its motor and serve as cooling agents and bearing lubricants. 4-p folder is from Allis-Chalmers Manufacturing Company

145 **Feed-pump recirculation control** based on temperature difference is topic of 8-p bulletin MSA-196. System uses feedwater-temperature rise through feed pump to regulate the recirculation flow. Controls Div, Hagan Chemicals & Controls, Inc

• Air compressors

146 **Horizontal compressors** in 300- to 2000-hp range for air and gas applications are introduced in 4-p circular A-74. Joy Manufacturing Company

147 **Compressed-air filter** checkup method uses a beam of light to

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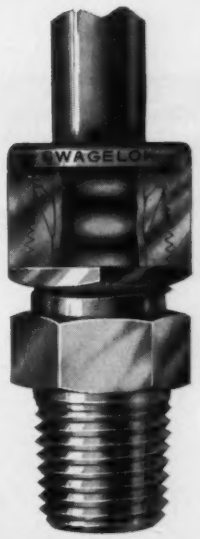

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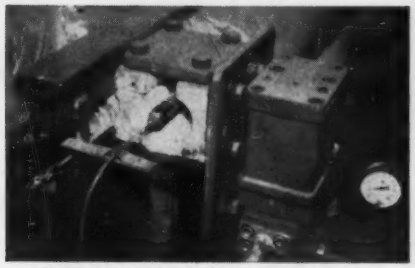
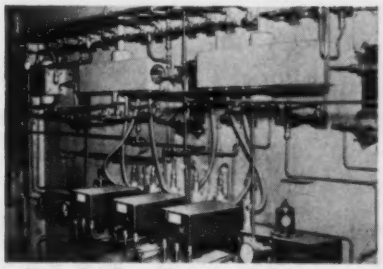


Swagelok Tube Fitting used as a thermocouple connector on main steam header #1 for boiler control. Operating conditions: Steam at 5000 psig — 1200° F.



Swagelok Tube Fittings used in control systems of supercritical pressure boiler.

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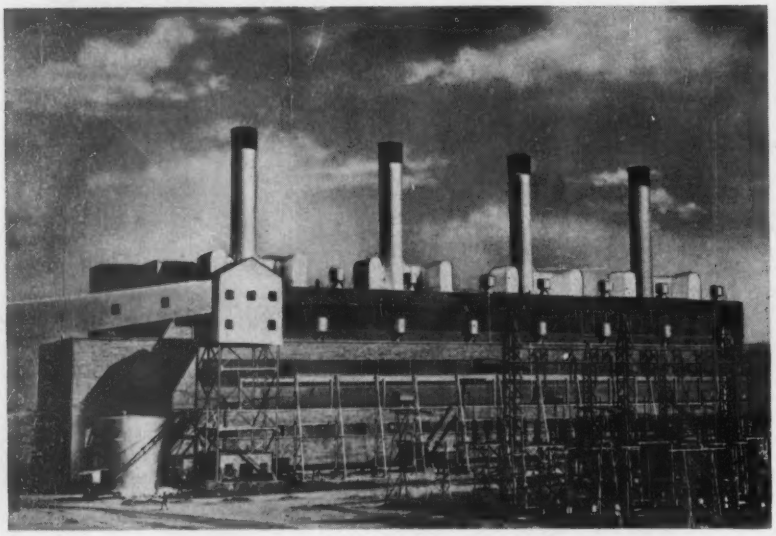

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Free literature

Begins on page 117A

tell how well your filter is working; subject of 4-p bulletin 751. King Engineering Corp

148 **Heatless dryers,** purifying systems and miniature compressors to produce clean, low-dew-point air and gases are topic of 4-p catalog 61. Applied Pneumatics, Inc

149 **Desiccant dryers** use no heaters, provide dew points below –100 F for compressed air or gas. 6-p publication is from Trinity Equipment Corporation

150 **Air-cooled compressors,** 1/3 to 20 hp, are featured in 28-p booklet 3400-B1. Covered are: 1-stage fractional hp, 1- and 2-stage bare, 1-stage, 2-stage tank mounted, 1- and 2-stage base mounted, 2-stage 3-cylinder 15- to 20-hp units. Engineering data answers compressor questions. Worthington Corporation

151 **Gas regulators** and their accessories are classified according to use so you can find them easily in 40-p catalog ADC 705G. Gases controlled: acetylene, oxygen, argon, helium, carbon dioxide, nitrogen, compressed air and more. Air Reduction Sales Company

• **Controls**

152 **Analogger** for flow recording is described in 8-p publication 201.1. Optional accessories — recording receivers and integrators—are discussed. Republic Flow Meters Company

153 **Hydraulic accumulators,** their operation, history, design and use, are subject of revised reference manual. Types mentioned: piston, mechanical bellows, spring loaded and bladder. Greer Hydraulics, Inc

154 **Pressure snubbers** — for high pressures, excess flow check and a sealed system—are illustrated in 4-p folder. Chemiquip Company

155 **Bypass rotameter** measures and controls flow rates in pipe sizes to 48 in. 8-p bulletin 116 gives info on capacity determination, flow range, piping requirements and accuracy. Brooks Instrument Company, Inc

156 **Flowsheet instrumentation** 4-p symbols brochure 91-53G-02 suggests symbols for process piping and lines, solenoids and other valves. They follow ISA recommended practice. Fischer & Porter Company

157 **Controlled feeding** of liquids and solids in process-industry systems is topic of 8-p catalog 4.20-1.

DAILY GRIND ALWAYS UNIFORM with Pennsylvania Reversible Hammermills

Regardless of condition of coal or amount of hammer wear—Pennsylvania Hammermills are noted for producing a highly uniform product day after day.

Basic design and simple adjustments available to the operator on the spot make this possible.

Pin point adjustments of cage-hammer clearance (by ratchet wrench and worm gear assembly) compensate for hammer wear or coal condition.

Crushing action keeps fines to minimum. Free air impact crushing in upper zone prepares coal so there is little dredging of hammers through oversize in cage-bar zone. Results—uniform grinds day after day.

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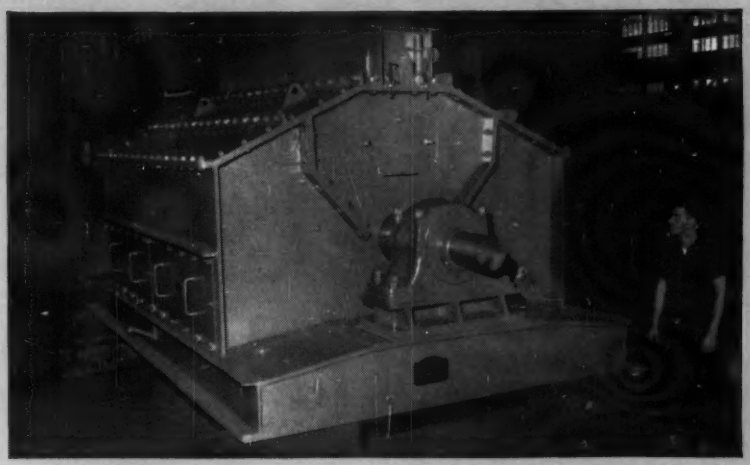
No other crushers give you so much more for your money. Pennsylvania Reversible Hammermills give double the crushing area—double the life of cage bars, breaker blocks and hammers. A flick of the switch; rotor is reversed and you are using a duplicate mill.

What's more, hammers need never be hand turned, and wear is kept uniform.



• Pennsylvania Reversible Hammermill for preparing bituminous coal for exact specifications of cyclone burner bin system, ready for shipment to large southern power plant.

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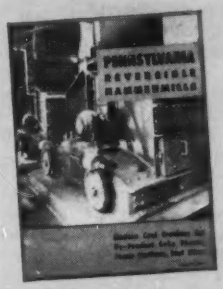

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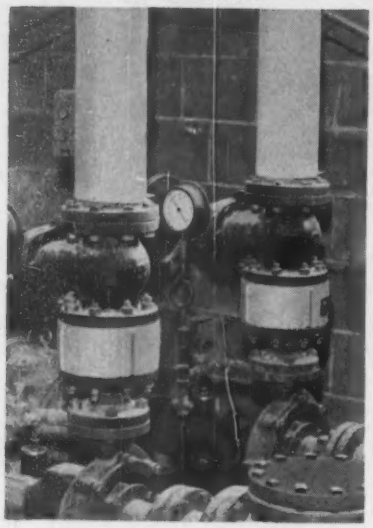
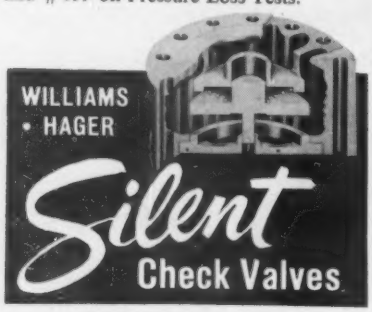


remotely-operated pumps are protected by Williams-Hager Silent Check Valves

Pumps on the condensate return system of the Glidden Company's Adrian Joyce Plant in Baltimore are operated by remote control. Since suction and discharge valves on the lines remain open at all times, check valves assure effective operation and protection of these pumps by closing instantly when flow reversal starts or when flow is zero—*without water hammer.*

• • •

For more information on Williams-Hager Silent Check Valves, write for these Bulletins: #851 on Cause, Effect and Control of Water Hammer; #654 on Valves; and #659 on Pressure Loss Tests.



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circle 268 on Reader Service card, p 117

Free literature

Begins on page 117A

Feeding, weighing, blending and proportioning equipment is described. B-I-F Industries

158 **Tankless system** synchronizes constant pressure, temperature, flow or liquid level with process rates and changes. 4-p folder 08C9989 is from Allis-Chalmers Manufacturing Company

159 **Adjustable flow alarm** is subject of spec sheet available from Schutte and Koerting Company, Instrument Div

160 **Hookups** for air-control regulators are diagramed in application guide A5B10. Steam-capacity tables are included in publication from Spence Engineering Co, Inc

161 **Liquid-level switches** in pneumatic or combination pneumatic-electric versions are described in 12-p booklet SF-765. Eight separate electric circuits are possible from one instrument. Fulton Sylphon Div, Robertshaw-Fulton Controls Company

Nuclear systems

162 **Electrostatic generators** for use in nuclear physics, insulation testing, X-ray generation and precipitation range from 50- to 600-kv output. 8-p brochure is offered by SAMES-U.S.A.

163 **Transducers** resist nuclear radiation. Available as gage, absolute and differential-pressure units, they measure ambient temperatures to 1000 F. 4-p folder is from Consolidated Controls Corporation

164 **Neutron generator,** a million-electron-volt unit, is described in 6-p bulletin. Neutron source tube, control panel and accessories are illustrated. Philips Electronic Instruments

165 **Radioactivity - monitoring** systems are shown in 4-p folder M-62. One detects radioactivity from airborne particulates, others monitor areas, liquids or gases. Nuclear Measurements Corp

166 **Sensor** case histories in 4-p brochure show how the devices provide beta - ray - measuring equipment for high-speed production lines and measure sheet-rubber thickness. Designers for Industry, Inc

167 **High-speed scalers** count radiation, operate with all basic nuclear detectors. Data sheet is available from Nuclear Measurements Corp

168 **Nuclear projects** undertaken by this firm—nuclear-power gen-

continued on p 127

just published!

STANDARD REFRIGERATION AND AIR CONDITIONING QUESTIONS AND ANSWERS

By STEVE ELONKA, Power Magazine and QUAID WALTON MINICH, Borg-Warner Corporation

Here's a practical book with quick answers to hundreds of questions on refrigeration and air conditioning. Gives you the information you need to work with greater ease and skill, and to pass license examinations. From fundamentals, through proper maintenance and servicing methods, to how to operate a large industrial plant—the entire field is covered. You get accurate answers to questions on refrigerants, compressors and condensers—controls, piping, lubrication, and defrosting—motors, cooling towers, and cooling water—and many other subjects. Packed with facts and working methods, the book covers the latest developments, as well as maintenance, servicing, and more efficient methods to help you win your license faster. Here, basic facts on how to operate plants at peak efficiency and how to keep equipment in top working order are presented in question and answer form. A special section gives you a complete listing of license requirements for operators in the United States and Canada. **268 pp., 155 illustrations and tables, $6.95**

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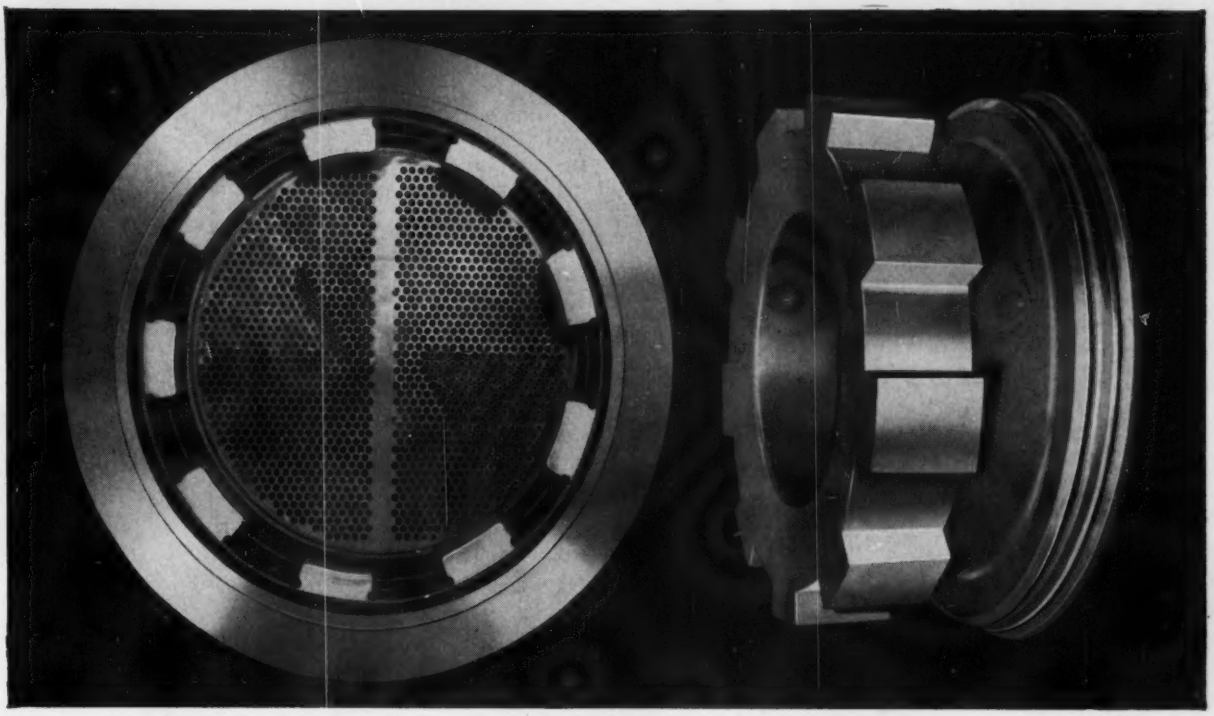


Simplicity and Easy Maintenance

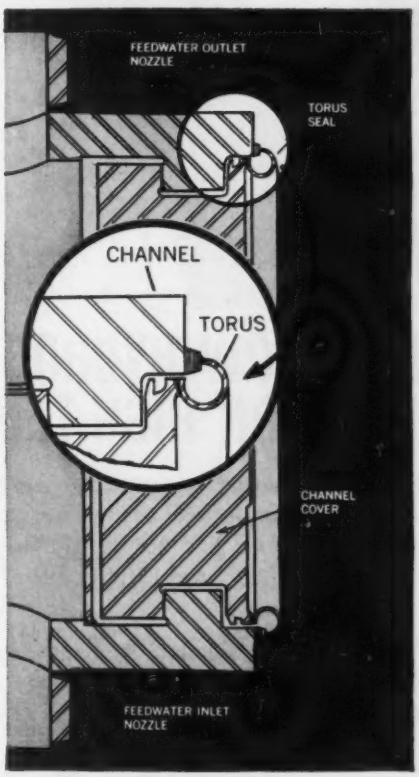
win quick acceptance for new FW Feedwater Heater Closure

Utilities had their first look at this gasketless Breech-Lockhead for feedwater heaters last year. Decisions to buy followed quickly among leading utilities including Pacific Gas and Electric, Omaha Public Power District, Toledo Edison Company, and Gulf States Utilities. Over 30 large high-pressure units have also been ordered for foreign utilities.

Why such fast acceptance by an industry which weighs every advance with extreme care? Because the FW Breech-Lockhead closure combines two proven principles—the torus and the breech-lock—the best way yet devised for achieving simplicity and ease of maintenance with a positive seal. The torus, welded to the edges of the channel and cover, provides a fully *leakproof seal independent of hydrostatic pressure.*

Disassembly and reassembly is quick and easy. When the torus is cut away from the channel, it remains attached to the pressure cover which may then be quickly removed. Simple tools make cutting, removal, replacement and rewelding a routine procedure.

If you are now considering feedwater heaters, get full information on this new FW Breech-Lockhead. It will simplify your maintenance. Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N. Y.



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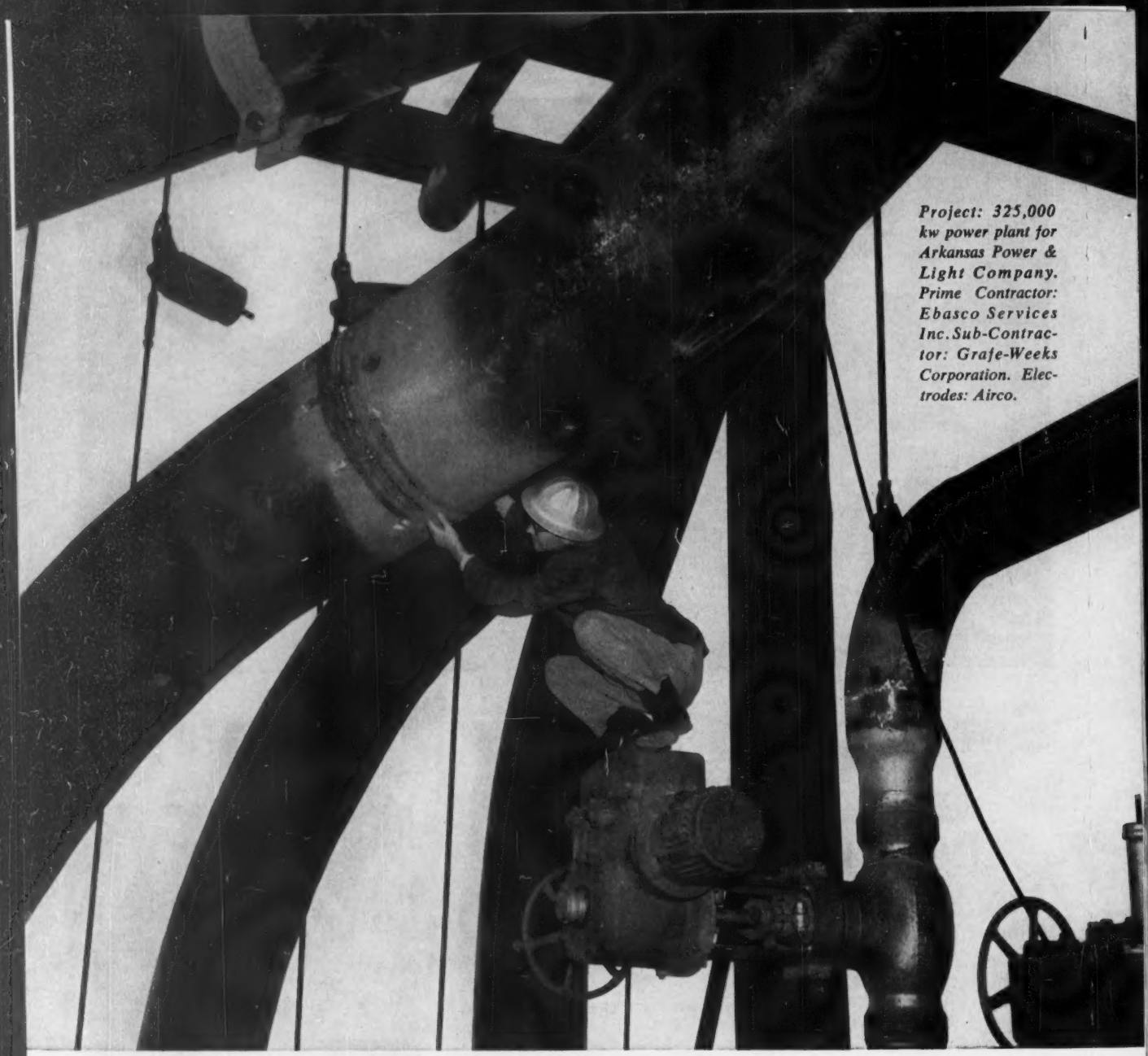

Project: 325,000 kw power plant for Arkansas Power & Light Company. Prime Contractor: Ebasco Services Inc. Sub-Contractor: Grafe-Weeks Corporation. Electrodes: Airco.

AIRCO LOW HYDROGEN ELECTRODES USED ON HIGH TENSILE PIPE WELDING *at giant new power station*

AIRCO LOW HYDROGEN ELECTRODES were used by Grafe-Weeks Corporation to weld the hundreds of feet of high pressure piping in the giant new steam turbine power plant of the Arkansas Power and Light Company at Helena on the Mississippi.

Why? . . . Because Airco low hydrogen electrodes provide an easily directed arc specifically designed to meet requirements of high pressure pipe welding . . . They also deliver X-ray quality deposits under tough conditions.

Ask for a shop demonstration. Would you like to see Airco electrodes put to the test? Let your Airco salesman or distributor arrange a demonstration at your convenience . . . using Airco low hydrogen electrodes or any other group of Airco electrodes. Call Airco, or look in your Classified Telephone Directory under "Welding Equipment and Supplies" for your nearest Authorized Airco Distributor.

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Free literature

Begins on page 117A

erating stations, processing plants and others—are listed in 6-p brochure. Burns and Roe, Inc

Mechanical-transmission systems

169 **Drives** from 5 to 200 hp operate on multiunit conveyors; details are given in spec sheets 112 and 110. The Louis Allis Co

170 **Adjustable-speed drives** and how to analyze, compare and select them: subjects of 32-p book GEA-6999. Units range from 1/20 to 1000 hp; their operation, components and controls are analyzed. Comparison table plots price curves against drive hp. General Electric Company

171 **Sprockets** with shear-pin hubs and split-taper bushings prevent overloading or jamming damage; they're detailed in 4-p folder CD-104-A. Browning Manufacturing Company

172 **Variable-speed changer** in 4-, 5- and 6-case sizes are described in 4-p circular 51B9061B. Spec sheet 51B1042 covers sizes 2 and 3. Both are available from Allis-Chalmers Manufacturing Company

173 **Gear speed reducers,** horizontal and vertical, are topic of 24-p handbook. Selection formulas are given for the spiral-bevel single-reduction right-angle units—input speeds from 100 to 1750 rpm, ratios from 1:1 to 6:1 and hp from 0.14 to 336. D O James Gear Manufacturing Co

174 **"Economics of V-band coupling"** is title of 16-p booklet SDP-2. Compares costs of V-band and other joining methods, discusses adaptability in filters, separators or containers. Marman Div, Aeroquip Corporation

175 **Adjustable centrifugal clutches** come in direct-drive, flat- and V-belt styles for electric or gasoline drives. Detailed in 4-p folder. Olme Precision, Inc

176 **Solid-woven belt** is made of PVC, neoprene and rubber for under- or above-ground use—featured in spec sheets 176, 177 and 178. Hewitt-Robins

177 **Variable-speed sheaves** rated from 2 to 15 and 7.5 to 20 hp are covered in 16-p bulletin 25103. Oil-lubricated units' companion pulleys and sheaves, belts, motion-control motor bases are pictured. T B Wood's Sons Co

178 **Dry-fluid drive** and coupling selection is simplified in 20-p bulletin 70. Weights, dimensions and prices of the fractional- to 1000-hp units are tabulated. Dodge Manufacturing Corporation

Energy-systems services

179 **Company's worldwide operations** are illustrated in 32-p booklet 1099-B54C. Plants, offices are shown with a history of company's development in that area. Worthington Corporation

180 **Electric-power surveys,** high-potential testing and locating ground faults are services detailed in 8-p brochure. A distribution system is evaluated, recommendations made for more economic, efficient uses of power. Electrical Surveys, Inc

181 **Wire and cable** manufacturing plant and its engineering and sales services in Calif. area are topic of 12-p brochure. Plant will supply line of hookup and vinyl-insulated wires and vinyl-jacketed cables. Brand-Rex Div, American Enka Corporation

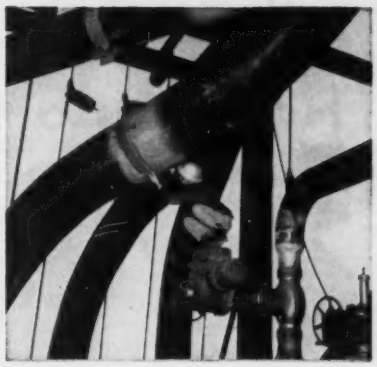
182 **Electronic librarian** searches technical articles, documents on metals for any mention of the subject at rate of thousands per hr. 8-p brochure discusses mechanized way to reduce research costs. American Society for Metals

183 **Research scientists**—can they acquire a management attitude is underlying question of 8-p discussion. Author makes point that management and research people have much in common. Battelle Memorial Institute

EDITOR'S NOTE: *The following bulletins may be requested directly from the manufacturer. Write on company letterhead to addresses listed below:*

★ **Quick-connect,** -disconnect coupling selection is feature of 62-p catalog. 500,000 different combinations are available. Packer guide points out seals to be used with fluids and gases at different temperature limits. Working pressure, flow, pressure drop and spillage data is given for each coupling. Snap-Tite, Inc, Union City, Pa.

★ **Instruments** and equipment for research, educational and industrial labs are subject of 1008-p book J-300. Sections: gas and air-pollution analysis, pH measurement, industrial testing, chromatography and constant-temperature devices. Central Scientific Company, Div of Cenco Instruments Corp, 1700 W Irving Park Rd, Chicago 13, Ill.



For your low hydrogen welding— Airco electrodes meet every critical need

Here are the Airco low hydrogen headliners — from a total of more than 100 Airco electrode types in more than 400 sizes and designs —

AIRCO 312 AWS-ASTM E60-7016. For welding higher strength alloy or carbon steels. Also high sulfur content steels. Designed to overcome "underbead cracking." Lessens need for high preheat or stress-relieving postheat.

AIRCO 396 AWS-ASTM E8016-C1. For welding the 2½% to 3½% nickel steels used in low temperature jobs. Also for nickel bearing steels, to provide uniform chemistry at joints with minimum difficulty. No high preheat needed.

AIRCO 395 AWS-ASTM E8016-C3, A 1% nickel type of low hydrogen electrode. Also for nickel bearing steels where good low temperature properties can be attained; high sulfur content steels; grade HT and similar high tensiles.

AIRCO 394 AWS-ASTM E10016-D2. For welding manganese-molybdenum high strength steels such as A-302 Grade B.

AIRCO 354 AWS-ASTM E8016-B2. For welding 1.25% chrome 0.5% molybdenum steels used for pressure vessels in high temperature service; and for castings of similar analysis.

NOW — "Barrier Carton" bars moisture damage. Special aluminum foil interlining in new carton now protects dryness of Airco low hydrogen electrodes *8 times better than regular style carton.* If your application can't tolerate moisture damage...specify Airco.

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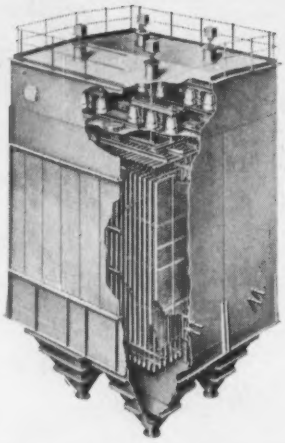
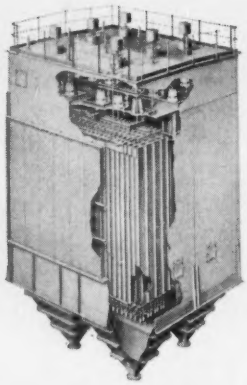
How to Evaluate Cottrell Precipitators

How Important Is Precipitator Size?

Traditional Design →





Modern Design ←

As shown in these two illustrations, Research-Cottrell's more compact modern design is appreciably smaller than the traditional design.

A common fallacy assumes a larger precipitator with lower gas velocity is preferable to a smaller precipitator with higher gas velocity.

This assumption overlooks important economies now obtained with:

(a) Efficient voltage application.

(b) Specific control of electrical sections.

(c) Electrode design improvements.

(d) Automatic Rapper Control.

(e) Accurate internal baffling.

(f) Proper control of gas flow, based on three-dimensional model studies.

Close familiarity with these techniques and improvements has made possible guarantees of 99 per cent collection on large, modern installations.

A. Applied Voltage

The relationship between voltage and size of the precipitator is approximately as shown in Figure 1.

Most efficient operation and minimum size are obtainable by insuring operation at maximum voltage under varying conditions of gas flow, particle size, resistivity, etc. Generally, the amount of arc-over in the precipitator will determine the practical operating voltage limit. By using the arc-over as the motivating control factor, through measurement and integration, maximum voltage can be insured at all times.

B. Sectional Voltage Control

Since gas conditions vary throughout any precipitator, higher efficiencies are obtainable if the precipitator is sectionalized with individual voltage control for each section.

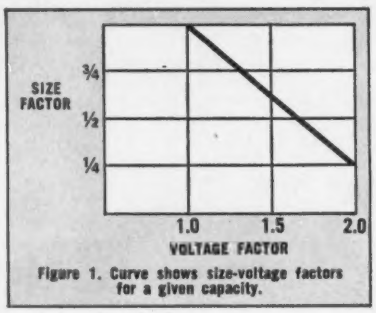


Figure 1. Curve shows size-voltage factors for a given capacity.

C. Electrode Design

Efficiency can be seriously affected by re-entrainment (that is the re-suspension of dust that has already been collected). Properly designed collecting electrodes, or plates, providing correct baffling to shield the collecting surface against the sweeping and scouring effects of the gas stream can reduce overall precipitator size 25–50 per cent.

D. Automatic Rapper Control

Rapping intensity must vary to meet the changing conditions of gas flow, particle size and resistivity. Otherwise, efficiency will decrease due to either too heavy a blow causing a re-entrainment, or too light a blow allowing dust build up on the electrodes necessitating operation at reduced voltages. Automatically controlled, fully adjustable rapping equipment insures optimum operation at all times.

E. Internal Baffling

Maximum efficiency can only be obtained by reducing the sneakage (part of gas stream which leaks or sneaks around the treatment zone) to an absolute minimum through the proper design and use of internal baffling proven by model studies and research on full size precipitators.

F. Gas Flow—Model Studies

Proper gas flow patterns across the face of the precipitator can result in a 25–50 per cent reduction in over-all size. The use of transparent plastic three-dimensional model studies as well as field research has resulted in refinements in design never before possible.

Only at Research-Cottrell can you be assured of these latest of design techniques and improvements providing the most economical selection of equipment and efficiency of operation. Research-Cottrell personnel, backed by nearly a half century of gas cleaning experience, stand ready at any time to provide information or service.

For details or more information relative to the data contained herein, or any other general inquiries, please contact your nearest Research-Cottrell representative or write directly to:

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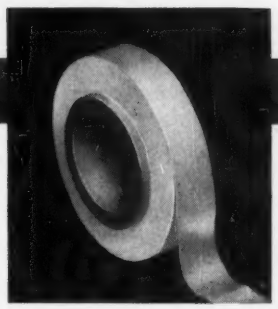

ANKLON THREAD SEAL®

Makes Pipe-Doping Clean, Quick and Easy!

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Features and Specifications

Easy to Carry: Flat ½" roll contains 520". Other sizes on special order.
Only One Wrap-Around Needed for Many Pipe Sizes.
Effective at Temperatures from −450°F. to +500°F.
Chemically Inert—Protects Joints from Corrosion.
Will Not Cause Contamination.

*DuPont's trademark for its TFE-fluorocarbon resin

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Plant equipment news... Your

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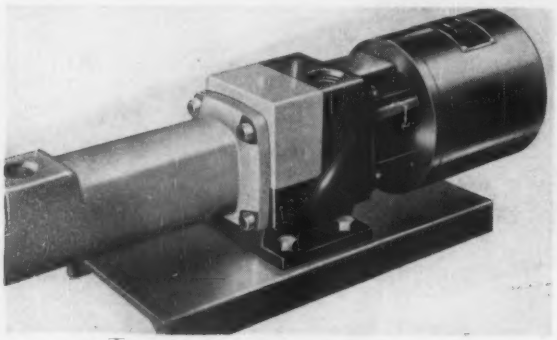


Boiler-feed pump combines features of turbine pumps and centrifugals

1 • Pump has a 5- to 150-gpm range with heads to 700 ft, runs at a maximum 3500 rpm and 2-ft npsh at all heads. As head drops, pump capacity and brake-hp pickup are nominal, so there's no threat of motor overload or cavitation when boiler pressure is abnormally low. According to maker, efficiencies will average 50 to 55% at normal operating conditions, comparing favorably with centrifugal designs and regenerative turbine pumps. Because shutoff head is the same as on a conventional centrifugal, pump lends itself to throttling feedwater regulators. It's available for flexible-coupling drives; with suitable adapters it also serves on the nonelectrics.—Fred H Schaub Engineering Co

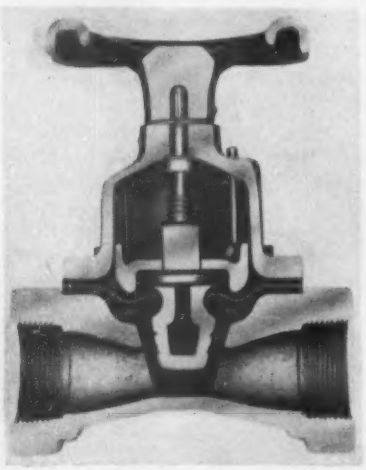
Finned tubes increase surface area

3 • Large-dia finned tubes find applications in processing furnaces and waste-heat boilers. Fins provide ten times more outside surface area per ft of length; tubes and piping can be used wherever bare pipe or tubing would be suitable. Helical fins are wrapped tightly into grooves plowed on the outside of the tube or pipe. Metal displaced by the grooves is then forced against the sides of the fins, forming a tight metal-to-metal bond. Available on 1- to 6-in.-dia pipes or tubes.—The Griscom-Russell Co

Absorption unit has unique gas burner

4 • To produce chilled water, the 15-ton air-conditioning unit gets its energy from a gas-fired burner using 2-effect generators. Plain water is the refrigerant and harmless lithium bromide the absorbent. A small motor-driven pump, the only moving part, circulates these in the sealed-for-life system. In the 2-effect cycle, one Btu is removed from the unit for each Btu of heat supplied, now making cooling as inexpensive as heating. Chiller cannot be damaged by overloading, continuous operation or cycling. The 15-ton unit conditions moderate-sized buildings—models with capacities up to 250 tons to come. Price tag on the 15 tonner reads $3500.—Statham-Swearingen, Inc

Metal-to-rubber bonding is a valve feature



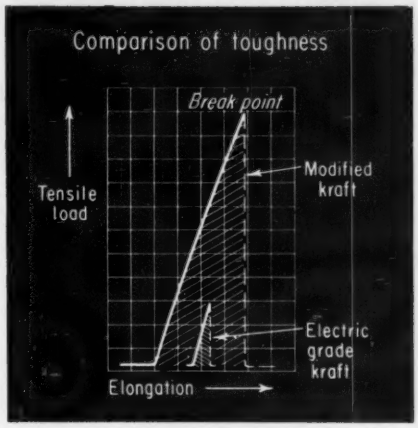
2 • Straight-flow valve is said to combine the versatility of diaphragm valves—it handles gases, fluids, vacuums and slurries up to 180 F and 150 psig—with greater flow capacity—up to 60%—and packless design of gate valves. Rubber and fabric diaphragm is molded to a metal wedge plug; this plug provides variable throttling or a positive seal at about 90 deg from line of flow. Because throttling characteristics are better, valve can be used with any type of instrumentation. Semiventuri body accelerates flow, lowers static pressure. Size range ⅜- to 8-in. dia.—Ohio Rubber Company, Cryogenics Corp

New line of small boilers

5 • Manufacturer now offers a complete line of small packaged hot-water boilers. Company is branching out from its 15- through 600-hp packaged-boiler range into the smaller heating market with 16 models designed for small buildings. Boilers produce 200,000 to 3,000,000 Btu, vary in price from $300 to $3000. In addition to area heating, the new boilers heat water and can be used with steam-absorption air-conditioning systems on a year-'round basis. First models to appear will be gas fired; oil-fired and low-pressure steam boilers will be available in the near future.—Cleaver-Brooks Company

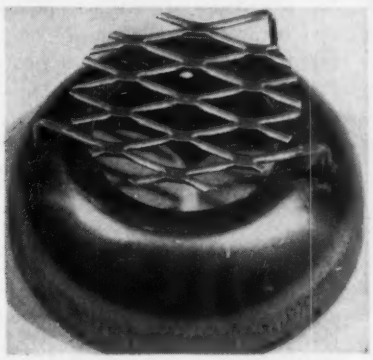
information center for new products and materials

Paper insulation for oil-filled transformers



6 • Modified cellulose has an improved thermal stability when aged in oil, permitting operation of transformers at higher temperatures and a reduction in size and weight of transformer shells. The modified kraft paper is also produced in tape and board form. Under accelerated aging conditions—immersed in oil for 14 weeks at 150 C—it shows a significant improvement over electric-grade kraft, maker states. Toughness, one of the evaluating factors, is shown at left. The new insulation is distributed throughout the company's divisions. —McGraw-Edison Company

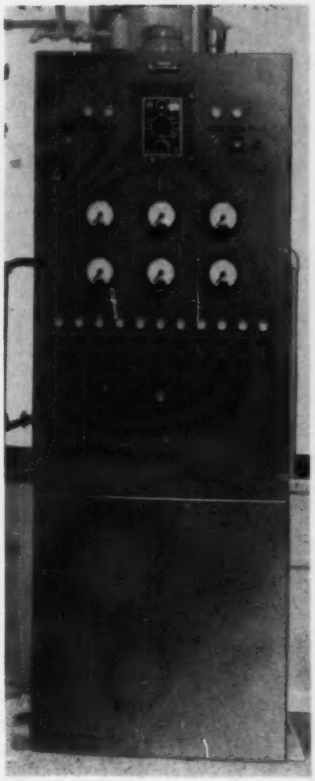
Grid improves combustion in high-pressure oil burners



7 • Oil burners using No. 3 fuel oil can now be equipped with a metal grid in front of the nozzle to improve the mixture of air and atomized oil. Maker says grid eliminates cold zone in the flame's hollow core and makes it more homogeneous, thus speeding up combustion and raising system efficiency. Unit consists of a nozzle shield, a wide-mesh screen and electrodes with electronic ignition control, costs under $60.—Humble Oil Refining Company

Filter serves in event of nuclear attack

8 • A 3-stage fallout filter is designed to provide the greatest possible protection against large and small radioactive dust particles, chemical and biological agents and poisonous gases. Radioactive dust particles as small as 0.3 microns and bacteria up to 99% will be removed; activated-charcoal filter will take care of toxic gases. Encased in a steel frame, filter can be placed either inside or outside the underground shelter.—Barnebey-Cheney



Controls insure supply of demineralized water

9 • Automatic starting, stopping and regenerating controls are now available for maker's mixed-, 2- and 4-bed demineralizers in capacities to 2500 gph. When ion-exchange resins are exhausted, they're backwashed, regenerated with acid and caustic solutions and the beds are rinsed. Controls provide purity safeguards for continuous testing; if water doesn't measure up, it's diverted to waste until the condition is corrected and water quality improved. Monitor activates equipment when storage tank water level gets below preset point.—Barnstead Still and Sterilizer Co

For more data on these developments, circle key numbers on Reader Service card, p 117

With
W & T
Treatment Equipment

Now you can take the sting out of cooling-water contaminants, solve treatment problems with chlorinators and pumps by Wallace & Tiernan.

For biological control there's intermittent desliming.

W&T chlorination kills slime and spores, never lets growth affect heat-exchange capacity. Job-proportioned V-notch Chlorinators feed up to 8,000 lbs. of chlorine per day. Treatment is efficient and economical. You get reliable control. Heat-exchange surfaces stay slime-free.

For pH and corrosion control there's chemical feeding.

The Wallace & Tiernan Series 100 Pump feeds chromates or acids at rates of up to 50 gph or boiler-treatment chemicals against pressures up to 1200 psi. The pump's unitized construction means lifelong accuracy, reduced maintenance. Choose one or two liquid ends, with individual stroke adjustment, to double capacity or feed two chemicals simultaneously. Where high pressures are not a problem, W&T Diaphragm Pumps also give reliable feeding of 1 to 500 gpd. Heat-exchange surfaces stay corrosion-free.

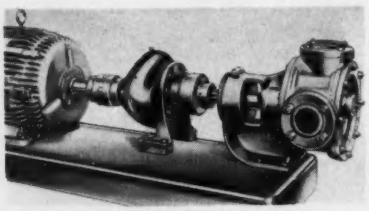
With Wallace & Tiernan Chlorinators and Pumps you keep condenser tubes clean and sound, assure heat-exchange efficiency.

For more information, write Dept. S-149.76.

WALLACE & TIERNAN INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

For more facts circle 275 on Reader Service card, p 117

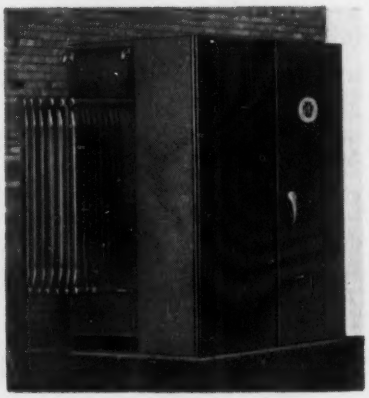
Equipment news



Helical gear-driven line gets new additions

62 • Three larger-capacity pumps have been added to this maker's line of helical-gear-driven units. These include the 200-, 300- and 450-gpm positive-displacement rotary units suitable for pressures up to 200 psi. Compact, independently mounted reducer, designated C, accepts any of five gear ratios capable of transmitting a maximum 25 hp at 350 pump rpm and 40 hp at 520 rpm. The three pump sizes with either a 1750 or 1150 rpm motor permit a capacity range from 65 to 450 gpm. Size C reducer has also been added to the line of smaller pumps, 50 through 150 gpm, permitting this series of pumps to be operated up to the maximum 200 psi.—Viking Pump Company

Just circle key numbers on the Reader Service card, page 117, to get complete product story

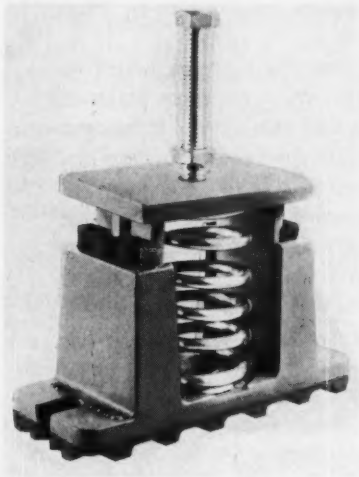


New 3-phase power center needs no fences

39 • Appearance and space were considerations here: power centers need no fences or overhead structures —or underground vaults. All live

Begins on page 130

parts are in tamperproof compartments; primary cable enters underground. Sizes: 750 through 2500 kva, 15 kv and below.—Pennsylvania Transformer Div, McGraw-Edison Company



Spring isolation mount

21 • Low-cost compact mount cuts equipment installation time, stops vibration, shock and noise transmission, according to maker. A single helical-coil steel spring is the cushioning medium. Four different springs are available in load-carrying capacities from 50 to 540 lb. They're interchangeable in the cast-semisteel isolator housing. Access port on each side lets you change spring in the field without taking the whole installation apart, so if you add weight to a machine, you can immediately compensate with a stiffer spring.—The Korfund Company, Inc, Shock and Vibration Div

General-purpose soft packing

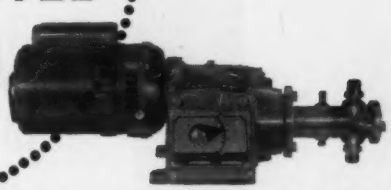
22 • Soft packing is recommended for solvent, mild acid or mild alkali service. Powdered-Teflon asbestos-fiber core is covered with a single nonmetallic braided - asbestos - yarn jacket impregnated with Teflon. The soft core suits this packing to use as an out-of-square valve-stem ring. Available sizes: ⅛ through 1 in.—Garlock Inc

continued

NOW, GET

BIG PUMP

FEATURES



IN A SMALL PUMP

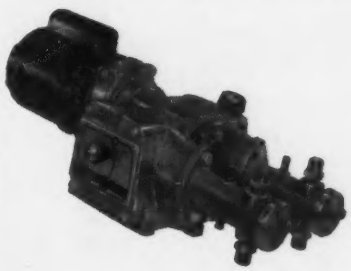
The New W&T Series 100

The Wallace & Tiernan Series 100 Metering Pump borrowed its design from W&T's Heavy Duty Pumps. Big-pump features are retained. Only size is scaled down for jobs like boiler-feed-water treatment.

The Series 100 Pump is one enclosed unit. There are no exposed moving parts. Motor and drive transmit thrust in a straight line. Pumping forces are absorbed by the heavy gear case. There are no rocker arms, no base-plate loads to twist components out of alignment.

Spring-loaded stuffing box assures proper pressure on the packing, prevents over-tightening, automatically adjusts for wear. Packing is easily replaced.

Stroke length is adjusted over a 10 to 1 range while the pump is running. Even in the double simplex, each liquid end is individually adjusted.



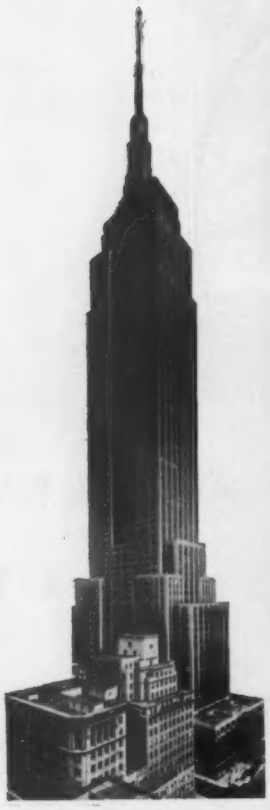
The Series 100 Pump delivers 3.2 gph vs 1200 psi, 50 gph vs 100 psi, repeatable within ±1%. You get big-pump performance at a small- capacity price.

For more information, write Dept. L-10.76.

WALLACE & TIERNAN INC.

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

For more facts circle 276 on Reader Service card, p 117



How Empire State Building and American Airlines solved vital fire protection problems with EVERLASTING VALVES

102 stories, 1,472 feet high, 16,000 tenants and 35,000 visitors sum up the fire protection problem of the Empire State Building. An in-building fire protection system is necessary to an unfailing water supply.

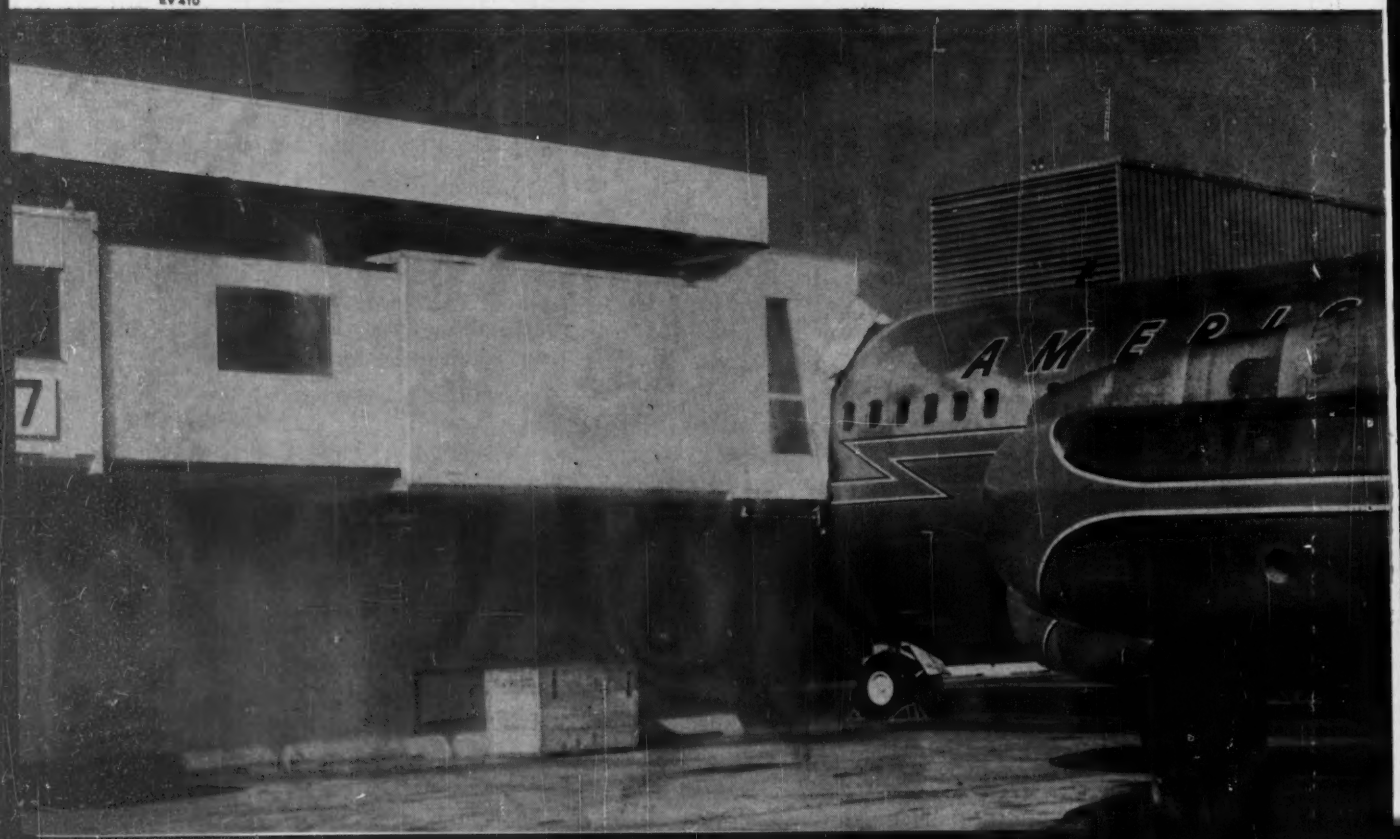
American Airlines loading bridge, shown below, gives passengers positive protection against fire with a unique deluge system.

Both these fire protection systems depend on Everlasting Pendulum Stop Valves, which have been installed in thousands of critical fire protection systems over the past 35 years.

For complete information on the unique American Airlines and Empire State Building systems, write for bulletins F. They include an editorial description of both these installations and a bulletin describing Everlasting's positive action pendulum stop valves.

Everlasting also makes a line of quick-opening valves for general service, boiler blow-off, and handling viscous materials, as well as a line of cylinder-operated valves. Bulletins on all these valves are available. **Everlasting Valve Company, 45 Fisk Street, Jersey City 5, New Jersey.**

EV 410

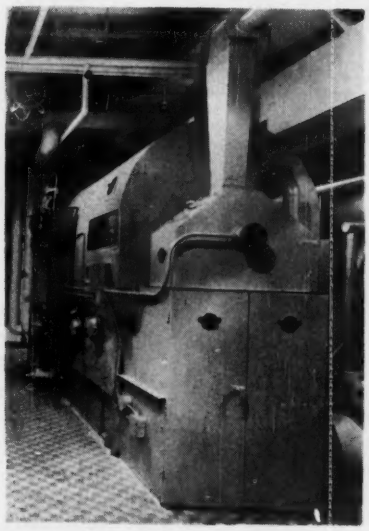


Begins on page 130

pH-analyzer system

25 • Industrial analyzer uses solid-state electronics, low-cost plug-in components. System includes model J analyzer, new electrodes and electrode-mounting chambers. It's reliable, flexible and convenient, according to its maker. Ac-stabilized amplifier is stable to 0.01 pH in 24 hr at ambient temperatures ranging from −20 to +122 F. Output accuracy and meter sensitivity is ±0.02 pH for full range of 0 to 14 pH.—Beckman Instruments, Inc, Scientific and Process Instruments Div

Just circle key numbers on the Reader Service card, page 117, to get complete product story



Coal-fired packaged boiler

32 • Package combines boiler, stoker, combustion-control system, coal and ash conveyors. Operation is completely automatic, says maker: coal is picked up at bin, transferred to a storage hopper. When the boiler needs to be fed, controls start up the stoker; with boiler satisfied, equipment slows to standby. Boiler operates anywhere from 10 to 100% of capacity and any number of them can be installed in tandem.—Canton Stoker Corporation

continued

A Westinghouse Metal-Clad Switchgear advantage to you:

Isolated center coil arc chutes on DH breakers provide better magnetic field distribution and strength to increase arc interruption efficiency

For complete facts on Westinghouse metal-clad switchgear using DH magnetic air circuit breakers, contact your Westinghouse representative or write to Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.
You can be sure... if it's **Westinghouse**

J-61019

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For more facts circle 278 on Reader Service card, p 117

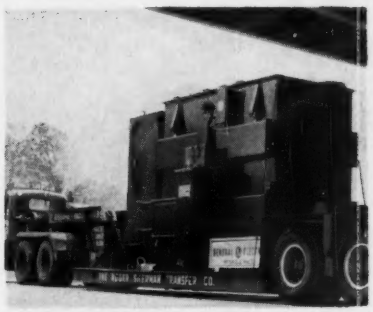
"K&M" ZEBRA Pipe Insulation *proves its toughness before it leaves home!* In torture tests by hard-to-satisfy K&M engineers, "K&M" Zebra® proves its ability to withstand heat, shock and vibration. Its multi-layer, sectional-type construction of calcium-silicate—asbestos bonded felts requires no babying on the job. Demonstrates a deflection at breaking point 2 to 4 times that of ordinary insulation. Stands up under periodic removal for line inspection. "K&M"® Zebra Pipe Insulation prevents heat loss indoors and outdoors, through a temperature range from 200 F to 1200 F. Its smooth, dust-free surface facilitates handling (no skin irritations or penetration). Half-sections and sizes available through 24″ pipe diameters. For more information, write: *Keasbey & Mattison Company, Ambler, Pa., Dept. I-1121.*

K·M BEST IN ASBESTOS

Keasbey & Mattison at Ambler

Equipment news

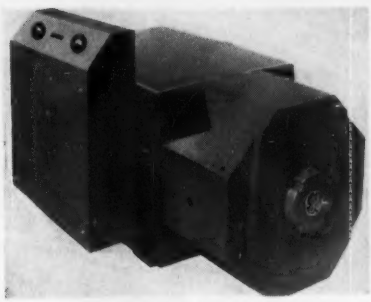
Begins on page 130



Power transformers redesigned for mobility

38 • Features of redesign: greater mobility, easier station changeouts, longer service life for these large substation transformers. Tank height is reduced to 12 ft—25,000-kva 115-kv unit above, en route to a utility sub, easily clears the underpass. Transformer's sealed-tank oil-preservation system cuts floor-space needs, maker states.—General Electric Company

Just circle key numbers on the Reader Service card, page 117, to get complete product story

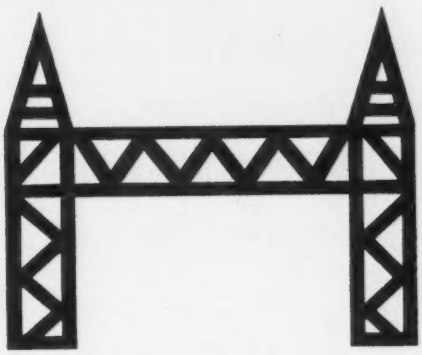


Brushless synchronous generators come packaged

42 • Available in 1200 and 1800 rpm through 350 kw, generators arrive ready to connect to drivers. Brushless exciter, static voltage regulator, ammeter and voltmeter all mount on the set. Hermetically sealed silicon diodes, used as rectifiers, rotate with exciter armature and main generator rotor.—General Electric Company

continued

A Westinghouse Outdoor Substation advantage to you:
Modular design substations let you make valuable time savings in engineering and erection, require minimum plot area and steel



For complete facts on modular design outdoor substations, contact your local Westinghouse representative or write to Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.
You can be sure... if it's **Westinghouse**
J-61020

For more facts circle 280 on Reader Service card, p 117

"I don't know who you are.

I don't know your company.

I don't know your company's product.

I don't know what your company stands for.

I don't know your company's customers.

I don't know your company's record.

I don't know your company's reputation.

Now—what was it you wanted to sell me?"

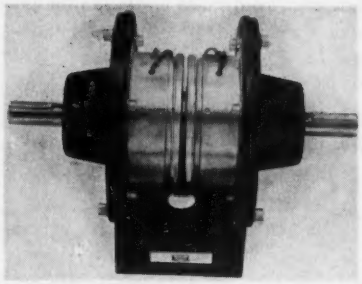
MORAL:
Sales start before your salesman calls—with business publication advertising.

McGraw-Hill
PUBLICATIONS

McGRAW-HILL PUBLISHING COMPANY, INC., 330 WEST 42nd STREET, NEW YORK 36, N. Y.

Equipment news

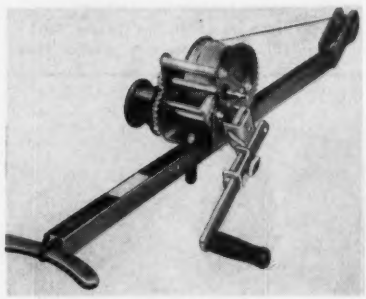
Begins on page 130



Electric clutch-brake

35 • To handle fractional-hp duty-cycle operations, electric clutch and brake are packaged with input and output shaft extensions, ready to bolt in and hook to power source. As many as several hundred machine cycles per minute can be accomplished.—Warner Electric Brake & Clutch Company

Just circle key numbers on the Reader Service card, page 117, to get complete product story



Now one man can pull wire through conduit

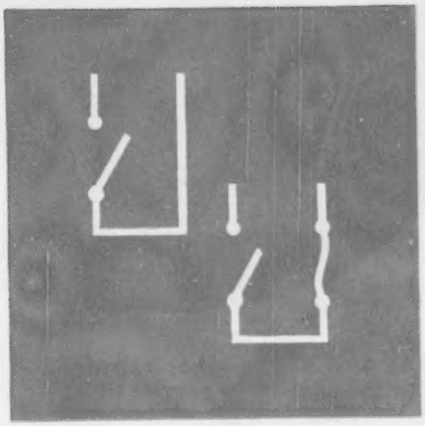
36 • Portable lightweight puller works without strain on the operator's part. Reinforced channel-steel frame carries double-reduction winch with 115:1 gear ratios. 200 ft of steel cable are rated to 2000 lb.—Hykon Manufacturing Co

Channel slot wedges endure high temperatures

33 • Wedges save winding space in slots of electric motors, generators

A Westinghouse Switchgear advantage to you:

Component selection in DFS drawout switch and fuse switchgear provides maximum application flexibility



For complete facts on DFS drawout switch and fuse switchgear, contact your local Westinghouse representative or write to Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.
You can be sure . . . if it's **Westinghouse**

J-61021

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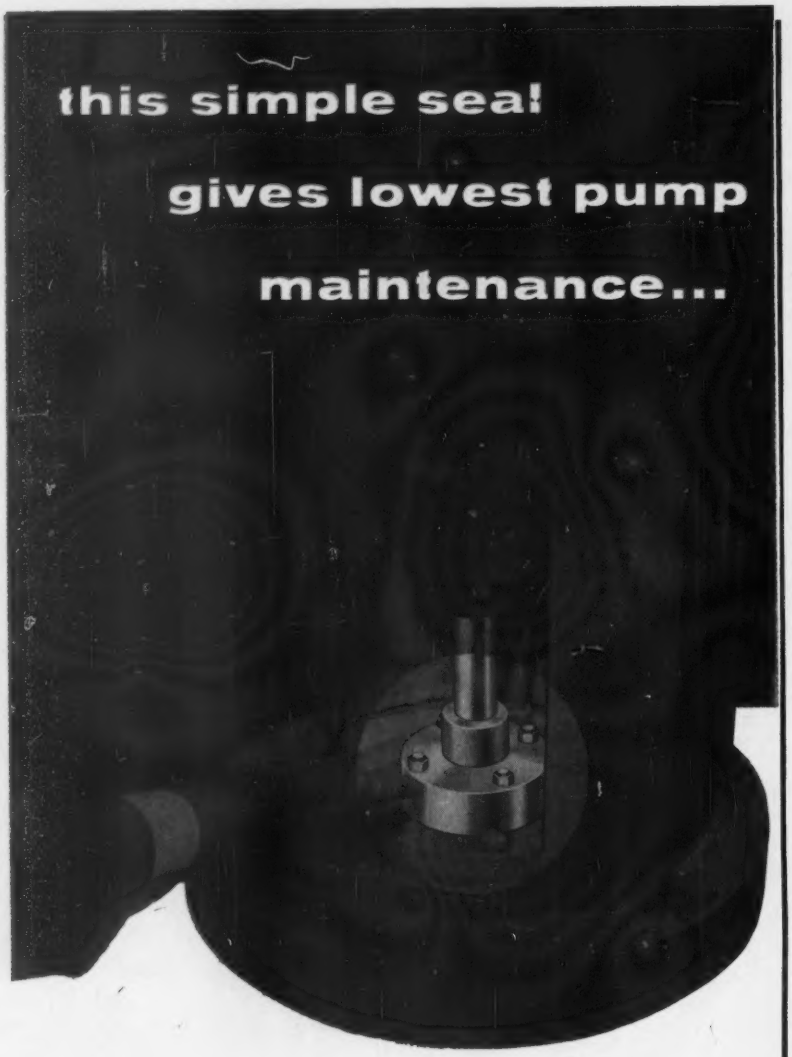
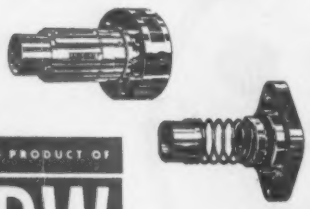


Save up to 66% of the time—expensive downtime—needed for installation or service of other mechanical seals used in plant process equipment.

The simple, effective Borg-Warner Type U Seal has no set screws—no close spring tension adjustments. It's fast and reliable.

For plants with a wide variety of pump service requirements, a minimum inventory of parts, and an easy change of gaskets adapts the Type U seal for service at temperatures of from —100 below zero to +650°F, and for pressures from 0 to 1000 psi.



Backed by Borg-Warner and proved in service, these dependable seals give complete safety, even in unattended stations.

Send for the latest Type U Seal engineering information —there's no obligation.

A PRODUCT OF B-W BORG-WARNER

Borg-Warner Mechanical Seals

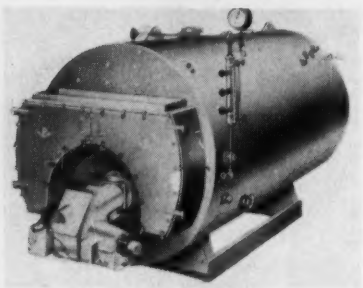
P.O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

For more facts circle 283 on Reader Service card, p 117

Equipment news

Begins on page 130

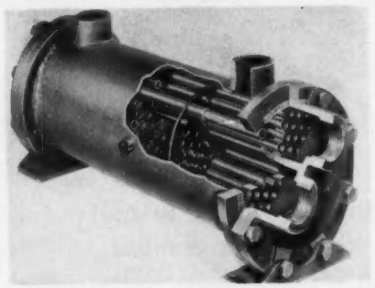
and other rotating equipment. They're made of woven glass cloth, laminated under heat and pressure: silicone-glass for Class-H service, epoxy-glass for Class-F and polyester-glass for Class-B. Each class is made in a separate color.—Silicone Insulation, Inc



F-d packaged boilers

24 • These wetback Scotch boilers come in a complete package made up of boiler, burner and all controls. Units are fired with No. 2 oil, natural, mixed or propane gas or an oil-gas combination. The seven sizes range from 2,000,000 to 5,540,000 Btu.—Portmar Boiler Company, Inc

Just circle key numbers on the Reader Service card, page 117, to get complete product story



Compact heat exchangers

26 • Shell diameters from 3¼ to 8¼ in., lengths from 16¾ in. through 6 ft 7 in. are available. Shells, connections and bonnets are ferrous, to make a strong, durable structure that withstands pressure surges and corrosion by oils and hydraulic fluids. Type 500 units have no hubs. Maker carries 1-, 2- and 4-pass models in stock for immediate shipment.—Basco, Inc

continued

NEW MORTON FLUITRON* ASSEMBLY ELIMINATES GRAVEL SUPPORTING BEDS

The all-plastic "Fluitron" is an exclusive Morton brinemaking device which makes possible exceedingly high brine flow rates while *completely eliminating* the need for gravel supporting beds when dissolving high-purity fine grained salts.

When used with Morton '999' or Purex all-soluble salts, the "Fluitron" insures a pure, saturated brine. It diffuses water through the salt bed and also collects the brine for discharge to the brine-use system. And by eliminating the gravel bed and expanding the salt capacity of your dissolving vessel, the "Fluitron" relieves you of frequent salt charging.

*Patent applied for

TAKE THE GRAVEL OUT OF YOUR BRINEMAKER AND KEEP IT OUT!

Adaptable to most brine make-up tanks, the "Fluitron" is included with Morton Model "E" Brinemaker series, or may be acquired individually on convenient leasing terms. Morton Brinemakers are now available in two corrosion-free materials —stainless steel or plastic. Write for complete information today.

☐ *Please send me complete information on Morton "Fluitron" and Brinemakers*

☐ *Please have a Morton Brine Engineer contact me regarding:*

*(type of problem)*_____

Name_____

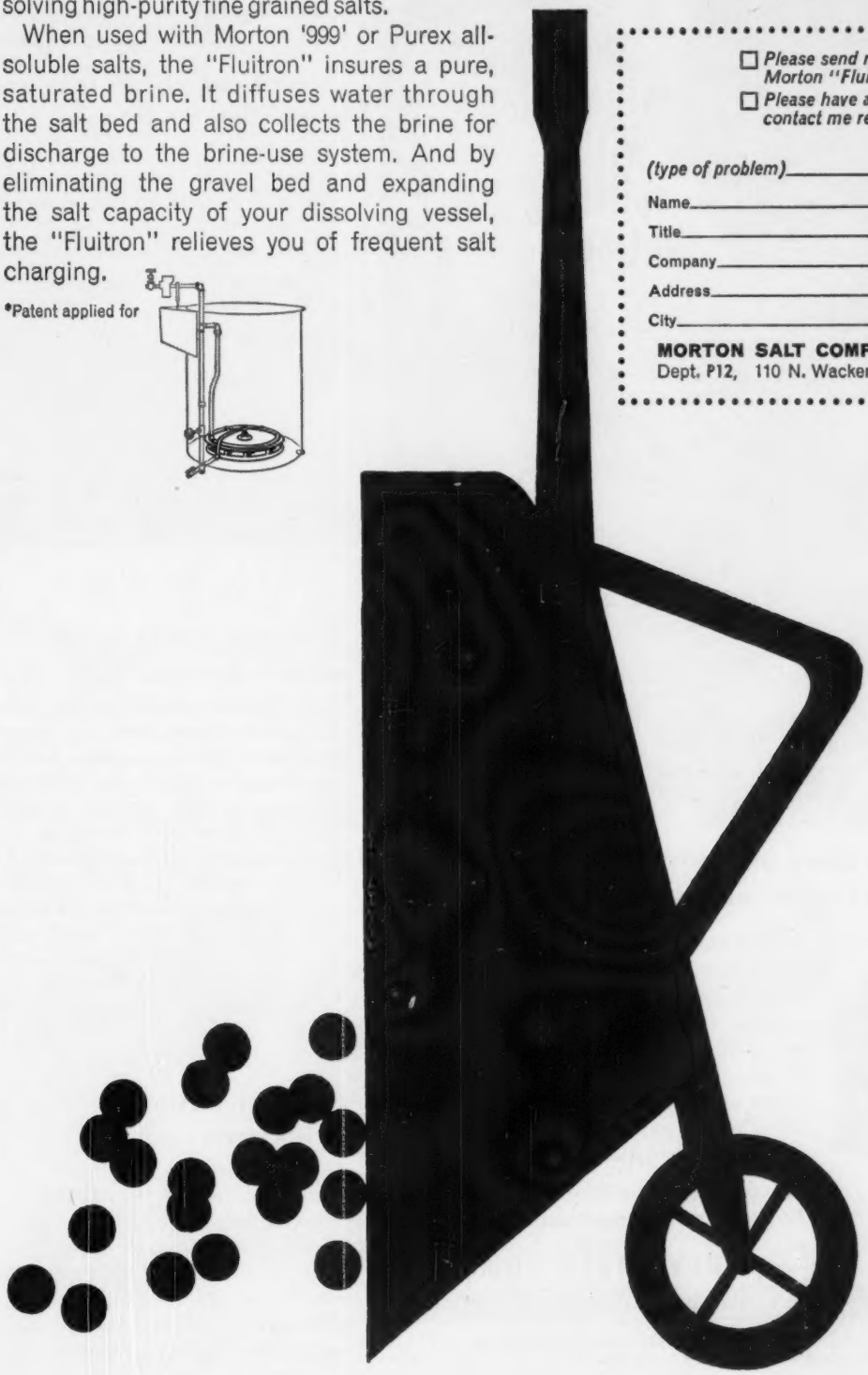
Title_____

Company_____

Address_____

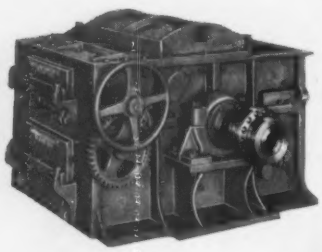
City_____ Zone____ State_____

MORTON SALT COMPANY Industrial Division
Dept. P12, 110 N. Wacker Drive, Chicago 6, Illinois



For more facts circle 284 on Reader Service card, p 117

American's inside story of: uniform sizing/minimum fines/no oversize/rapid reduction/less power cost



American Coal Crushers don't actually crush coal—they split it, along the natural lines of cleavage. A series of rugged manganese steel shredder rings, each with many cutting edges, quickly and cleanly reduce the coal to uniform size lumps. Because of the splitting action... troublesome fines are drastically reduced. It's the proven, efficient method of coal reduction.

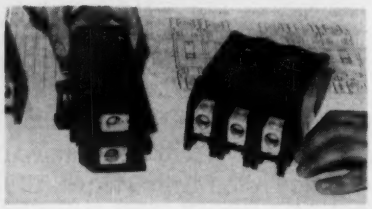
For complete information, write for bulletin on American AC Coal Crushers.

American PULVERIZER COMPANY
ORIGINATORS AND MANUFACTURERS OF RING CRUSHERS AND PULVERIZERS
1349 MACKLIND AVE. ST. LOUIS 10, MISSOURI

6130

Equipment news

Begins on page 130



Molded-case circuit breakers are smaller for economy

40 • These 200-amp circuit breakers are designed to combine economy with full protection. They measure 7 x 2-11/16 x 1½ in. for the 1-, 3 in. for the 2-, 4½ in. for the 3-pole models. Interrupting rating: 10,000 amp. Use them as circuit protectors on industrial l-v distribution systems, especially service entrances.—Westinghouse Electric Corporation

Just circle key numbers on the Reader Service card, page 117, to get complete product story

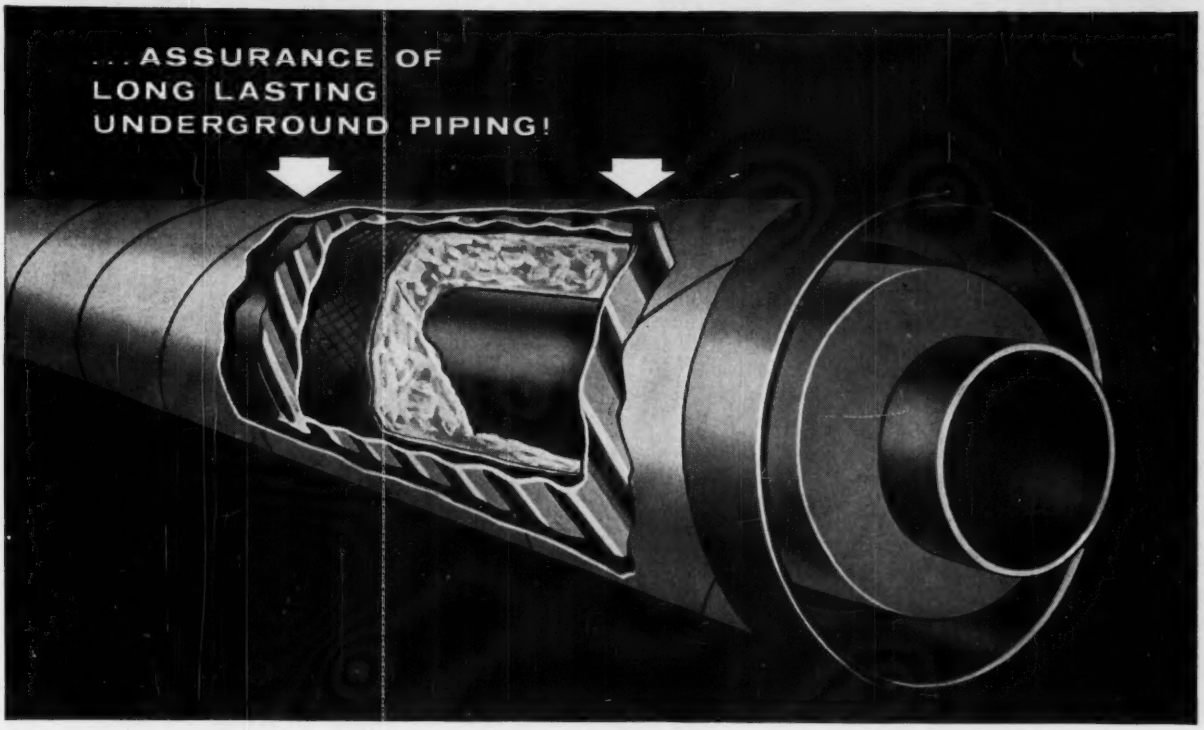
Solid-state control system expands its capabilities

64 • This company's first entry into the process-control field was introduced as an open-loop system. Now it expands to answer control problems ranging from data logging to fully automatic closed-loop control of industrial processes and test operations. A data converter and a multiplexer-terminal unit are added to the basic 1710 system for greater speed and closed-loop capability. System itself not operator, makes point-set adjustments.—IBM, Data-Processing Div

Polyethylene wire covering resists stress cracking

41 • Low-density polyethylene extrusion has high stress-cracking resistance. It's for use on line wire, service-drop cable. Tensile strength is 2300 psi, elongation 600%, brittle temperature –85 F. Deformation is still zero at 105 C, says maker.—Union Carbide Plastics Company

GALVANIZING

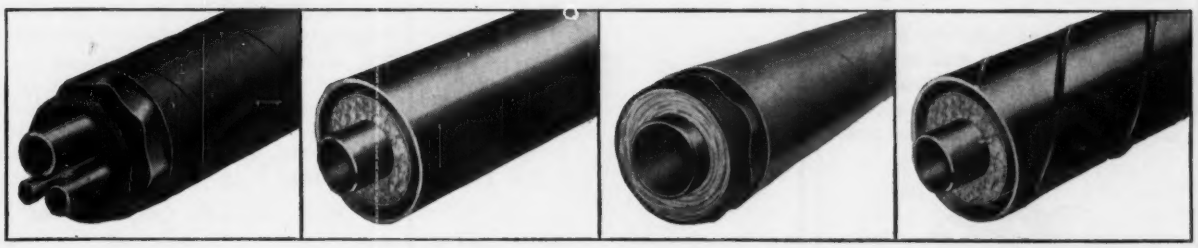


Hot-dip galvanizing of the Hel-cor Conduit in a Ric-wiL system offers the finest in corrosion protection. The Zinc actually alloys to the steel and becomes an integral part of the conduit . . . not just a surface coating. The Automobile Industry has announced through The American Zinc Institute that after testing 450 coatings, Zinc was best from the standpoint of resistance to corrosion.

The illustrated catalog offers a wealth of information on types of systems, engineering, specifications, and installation methods . . . write today for your copy. . .

OTHER AVAILABLE

RIC-WIL SYSTEMS...



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Quality Piping Systems . . .
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RIC·WIL PREFABRICATED INSULATED PIPING SYSTEMS

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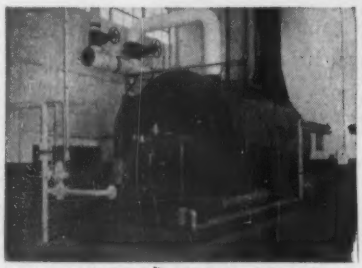
WESTERN STATES: RIC-WIL INCORPORATED, WESTERN DIVISION, NEWARK, CALIFORNIA
IN CANADA: THE RIC-WIL COMPANY OF CANADA LTD.

For more facts circle 286 on Reader Service card, p 117

ANOTHER JOHNSTON 750 h.p. PACKAGED BOILER PROVES ITSELF



750 h.p. Johnston Bros. oil and gas fired packaged boiler, installed at Hart & Cooley Mfg. Co., Holland, Michigan.

Hart and Cooley, world's largest manufacturer of registers and diffusers for heating and air conditioning, selected a Johnston Packaged Boiler to furnish heat and process steam for their expanding plant facilities.

Based on past experience with oil fired conventional boilers, Hart & Cooley were looking for a boiler that would require minimum maintenance and have low operating and installation costs. After thorough investigation they chose Johnston.

Detailed records have proven the wisdom of their choice. Mr. William Van Etta, boiler engineer, reports that since the installation of the Johnston Packaged Boiler, operating labor has been reduced from 160 hours per week to less than 30 hours. This labor reduction plus outstanding fuel economy, resulted in an average monthly saving of $1,825.00.

Johnston makes the boiler that fits your requirements. Sizes range from 20 to 750 h.p., pressures to 250 lb., with pre-heated or cold oil, gas or gas-oil combination burners. Write for Bulletin 509B and 200B.

Johnston

Johnston Bros., Inc.

FERRYSBURG, MICHIGAN

Pioneers of waterback boiler design.

Circle 287 on Reader Service card, p 117

Speaking of *POWER*

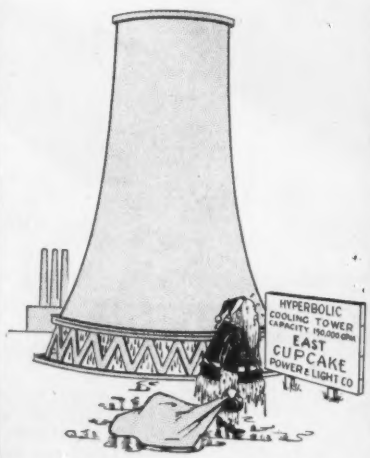
Begins on page 2

as Company representative to Ethiopia. Emperor Haile Selassie, for whom Bender has great respect, asked him to lecture to the people throughout the vast empire, letting them know what Sinclair was doing and what oil, if discovered, would mean to Ethiopia. Thus Bender delivered 47 lectures in English, French and Italian which were translated simultaneously into local Amharic.

During World War II Bender served in the U.S. Navy. "As an American naval officer," he says, "I had the pleasure of entertaining, at my headquarters in Dakar, French colonels and generals who had been my lieutenants and captains when I was a corporal in the French Army in World War I."

Bender made a number of memorable landings in Italy, Corsica and Southern France, and was part of a group of investigators who entered Germany with the first troops, to interrogate German scientists and engineers about their developments in fuels and the synthetics.

The "Ecole Centrale" in Paris, France is Bender's alma mater. The Chief is a member of the ASME, SAE and ACS. He is also a director and chairman of the lecture committee of French Engineers in the U.S. Inc. He worked as the refining and petrochemical editor of *Petroleum Week* before joining POWER.



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for Thermocouple Extension Wire Installations

Here's an economy team to increase efficiency and cut costs up to 75% in your next thermocouple extension wire installation. Multi-conductor THERMO-CABLE* permits you to install from 6 to 56 pairs of color-coded, insulated thermocouple leads, at one time, using just one cable. Terminate the wires in a weatherproof multi-terminal box specifically designed for THERMO-CABLE.

No more pulling individual leads through conduit. And, THERMO-CABLE, with its polyvinyl chloride weatherproof, heat and corrosion resisting outer sheath often eliminates the need for conduit. Direct burial types available to eliminate hazards from fire and mechanical damage.

T.E. weatherproof Terminal Boxes are made of cast iron or sheet steel, can accommodate from 6 to 100 circuits, and offer sure protection against the effects of contaminating atmospheres. Made to N.E.M.A. or JIC specifications.

Write today for Catalog 83-42

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Thermo Electric CO., INC.

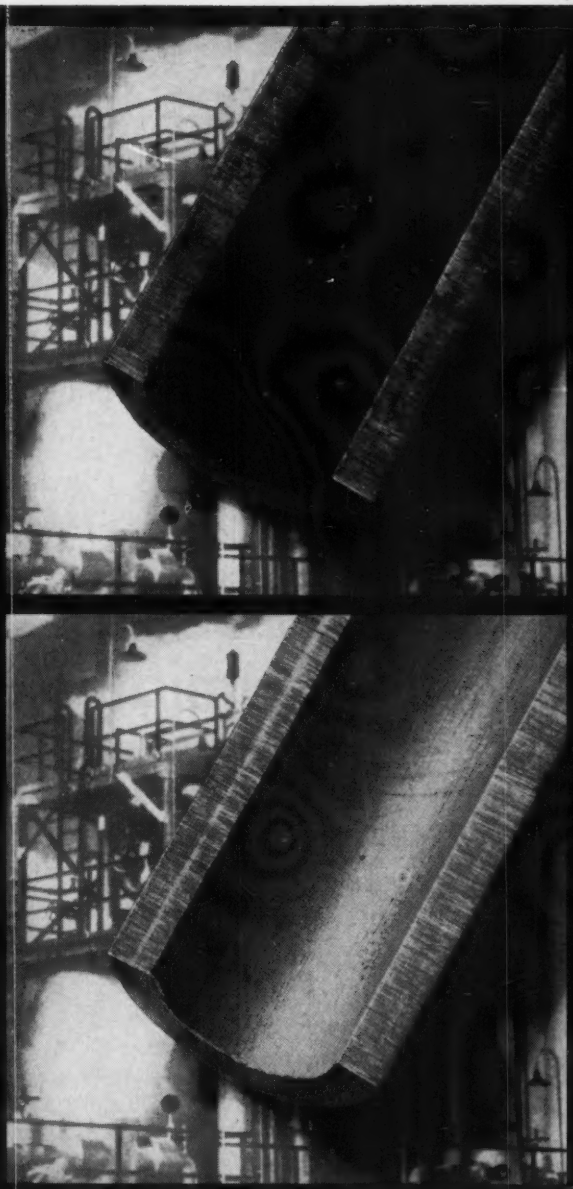
SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

Circle 288 on Reader Service card, p 117

BETTER OPERATIONAL CLEANING BEGINS...

WITH THE NEW PFIZER CITRIC ACID PROCESS



These steel tube sections taken from a typical boiler system were "look-alikes" until one was cleaned with ammoniated Pfizer Citric Acid.

THE ADVANTAGES OF CITRIC ACID FOR PREOPERATIONAL CLEANING are widely recognized. Now, a new Pfizer process—using ammoniated citric acid—has opened the door to safer, more efficient removal of ***operational*** iron oxides and copper deposits from high-pressure steam generating surfaces. Field testing has proved the process to be both effective and practical.

Important to the success of the process is the fact that ammoniated citric acid solutions are good solvents for iron oxide deposits. And, because of the citrate's sequestering properties, the redeposition of dissolved iron is prevented. Then, too, the same solution, with additional ammonia and an oxidant, dissolves and removes copper deposits.

This one-solution cleaning process, discovered by S. Alfano of Houston Lighting and Power Company, permits substantial reduction of total cleaning time by eliminating intermediate draining and refilling steps. (Actual cleaning operations have been completed in 8-13 hours.)

The ammonium citrate process leaves metal surfaces in a passive state—tendency to rerust is minimized—no special after-treatments required. When stainless steels are present, chloride stress corrosion problems are eliminated. Important too, citric acid is dry, nontoxic, water soluble and easily handled.

Chas. Pfizer & Co., Inc.,
Chemical Sales Division,
New York 17, N. Y.

I want to learn more about the use of Pfizer Ammoniated Citric Acid for cleaning steel equipment. Please send me Data Sheet 561.

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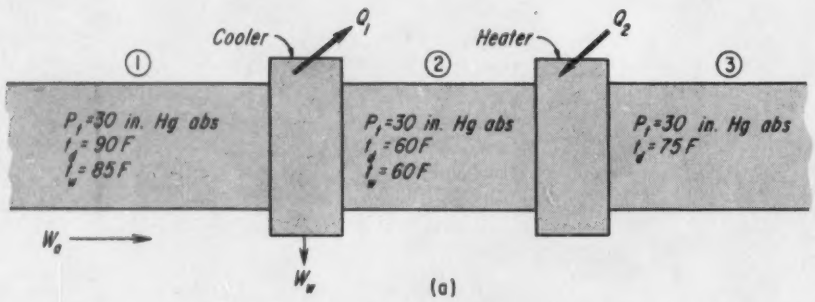


1 Air-conditioning system takes in atmospheric air and passes it through cooler to condense out some of the original vapor. Saturated air leaving cooler must then be heated to whatever final dry-bulb temperature is wanted. Heat Q_1 controls end humidity

THERMO REFRESHER NO. 55

By B G A SKROTZKI, Associate Editor

How to use humidity calculations

This final part of the *Refresher* series shows us how to apply psychrometric principles to three examples of practical air-steam processing systems and equipment

In parts 53 and 54, Sept and Nov '61, we took a detailed look at the relations of air and vapor in mixtures. Now let us apply some of the principles we learned in a few elementary processes.

Air conditioning takes in atmospheric air and changes its properties to increase human comfort or for some processing need. In Fig. 1 we begin with air that has a high vapor load. Dry-bulb temperature is 90 F and wet-bulb 85 F; total pressure equals 30.00 in. Hg abs.

We pass the air through a cooler to reduce its dry-bulb and wet-bulb to 60 F by removing heat Q_1. Then a heater raises the dry-bulb to 75 F by adding heat Q_2.

First let us find, from equation (4) of part 54, specific humidity of the entering atmospheric air:

$$\overline{SH}_1 = \frac{0.622 \times \frac{P_{sw}}{P_{aw}}(H_{sw} - H_{tw}) + 0.24(t_w - t_d)}{H_{sd} - H_{tw}}$$

Substituting the given data in this equation:

$$\overline{SH}_1 = \frac{0.622 \times \frac{1.2133}{30.00 - 1.2133}(1045.8) + 0.24(85\text{-}90)}{1100.9 - 53.0}$$

$$= 0.02514 \text{ lb vapor per lb dry air}$$

Now let's find the relative humidity of this air. First we must get partial pressure of steam in the mixture from:

$$\overline{SH} = 0.622\frac{P_s}{P_a} = 0.622\frac{P_s}{P_t - P_s}$$

$$P_s = P_t\overline{SH}/(0.622 + \overline{SH})$$
$$= 30 \times 0.02514/(0.622 + 0.02514)$$
$$= 1.204 \text{ in. Hg abs}$$

$$\overline{RH}_1 = (\overline{SH}_1/0.622)(P_t - P_s)/P_s$$
$$= (0.02514/0.622)(30.00 - 1.204)/1.4215$$
$$= 0.819 \text{ or } 81.9\%$$

A study of the T-S diagram in Fig. 1*b* shows that the mixture is cooled below the initial saturation pressure of the steam at 60 F, so part of it condenses to water w_w.

Steam tables tell us the partial pressure of the saturated steam, so we can figure the specific humidity of air leaving the cooler from:

$$\overline{SH}_2 = 0.622\,P_s/P_a$$
$$= 0.622 \times 0.5218/(30 - 0.5218)$$
$$= 0.01105 \text{ lb vapor per lb dry air}$$

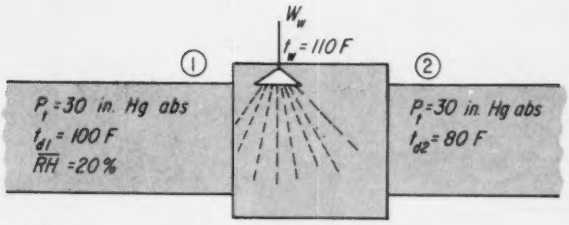
Then water condensed in the cooler is the difference of the specific humidities entering and leaving or:

$$w_w = \overline{SH}_1 - \overline{SH}_2 = 0.02514 - 0.01105$$
$$= 0.01409 \text{ lb water per lb dry air}$$

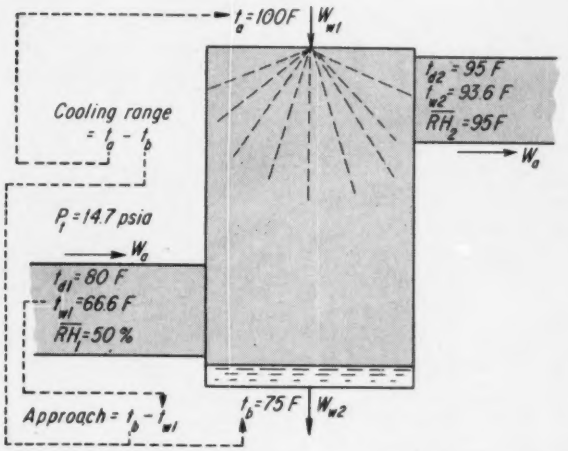
Now we're ready to figure heat removed by the cooler. We'll do this by relating everything to one lb of dry air flowing through the system. First we take a first-law energy balance about the cooler:

$$w_a H_{a1} + \overline{SH}_1 H_{s1} = w_w H_t + Q_1 + w_a H_{a2} + \overline{SH}_2 H_{s2}$$

Substituting (remember $w_a = 1.0$):



2 Simple spray system can cool entering air at expense of increasing final humidity. Water temperature has little effect



3 Cooling tower acts to take heat out of circulating water by evaporating a small part of it to raise humidity of the air

$$0.24\,t_{d1} + \overline{SH}_1(1060 + 0.45\,t_{d1}) = w_w H_f + Q_1 + 0.24\,t_{d2} + \overline{SH}_2(1060 + 0.45 t_{d2})$$

Entering data from Fig. 1 and previous calculations:

$$0.24 \times 90 + 0.02514(1060 + 0.45 \times 90) = 0.01409 \times 28.06 + Q_1 + 0.24 \times 60 + 0.01105(1060 + 0.45 \times 60)$$

Solving: $Q_1 = 22.46$ Btu per lb dry air

Heater process. Since no vapor leaves or enters the air-steam mixture after it leaves the cooler:

$\overline{SH}_3 = \overline{SH}_2 = 0.01105$ lb vapor per lb dry air

As we can see from Fig. 1*b*, partial pressure of the steam does not change either, so:

$P_{s3} = P_{s2} = 0.5128$ in. Hg abs

Then the relative humidity of the mixture leaving the heater is:

$\overline{RH}_3 = P_s/P_g = 0.5218/0.8750 = 0.5962$ or 59.62%

P_g is saturation pressure corresponding to 75 F. From the energy balance about the heater we get:

$$Q_2 = w_a(H_3 - H_2) = 0.24\,t_{d3} + \overline{SH}_3\,(1060 + 0.45\,t_{d3}) - 0.24\,t_{d2} + \overline{SH}_2(1060 + 0.45\,t_{d2})$$

Substituting:

$Q_2 = 0.24 \times 75 + 0.01105(1060 + 0.45 \times 75) - 0.24 \times 60 + 0.01105(1060 + 0.45 \times 60) = 3.68$ Btu per lb dry air.

Practical application of Fig. 1 and the data we figured will let us size some of the equipment. For example, let's assume the system takes in 1000 cfm of air at the initial conditions. We want to find total water and heats that must be handled.

First we must realize that:

1000-cfm atmospheric air = 1000-cfm dry air = 1000-cfm vapor

Weight of this 1000 cfm of dry air can be figured from $w_a = PV/RT$ where P must be in psfa and V is in cfm. Then:

$$w_a = 144(30 - 1.204)\,0.4912 \times 1000/53.3 \times 550 = 69.45 \text{ lb dry air per minute}$$

Weight of the vapor in the atmospheric air is:

$$w_s = 69.45 \times \overline{SH}_1 = 69.45 \times 0.02514 = 1.75 \text{ lb per min}$$

Total mass flow of atmospheric air is:

$w = w_a + w_s = 69.45 + 1.75 = 71.20$ lb per min

Heat abstracted by cooler:

$Q_1 = 69.45 \times 22.46 = 1560$ Btu per min

Since one ton of refrigeration equals 200 Btu per min we would need a refrigerator with a capacity of:

$1560/200 = 7.8$ tons

The refrigerator condenses $69.45 \times 0.01409 = 0.98$ lb of water per minute out of the air. This equals $(0.98/8.33)\,60$ or 7.05 gal of water per hr.

Spray cooling of air, Fig. 2, is often used for processing work and occasionally for comfort conditioning. Here we use water at 110 F to cool air initially at dry bulb of 100 F and $\overline{RH}_1 = 20\%$ to a dry bulb of 80 F. How much spray water must be evaporated?

First let's find the entering $\overline{SH}_1$ by figuring partial pressure of the entering vapor from:

$$P_{s1} = P_{g1}\,\overline{RH}_1 = 1.9325 \times 0.20 = 0.3865 \text{ in. Hg abs}$$

where 1.9325 is the saturation pressure at 100 F. Then:

$$\overline{SH}_1 = 0.622 P_{s1}/(P_t - P_{s1}) = 0.622 \times 0.3865/(30 - 0.3865) = 0.00812 \text{ lb vapor per lb dry air}$$

From an energy balance about the cooler:

$$w_a H_{a1} + \overline{SH}_1\,H_{s1} + w_w H_w = w_a H_{a2} + \overline{SH}_2\,H_{s2}$$

But note that $w_w = \overline{SH}_2 - \overline{SH}_1$. Substituting, we get:

$$0.24 \times 100 + 0.00812(1060 + 0.45 \times 100) + (\overline{SH}_2 - 0.00812)\,77.9 = 0.24 \times 80 + \overline{SH}_2(1060 + 0.45 \times 80)$$

Solving we find:

$\overline{SH}_2 = 0.01291$ lb vapor per lb dry air

Then spray water added to reduce the temperature to 80 F is: $w_w = \overline{SH}_2 - \overline{SH}_1 = 0.01291 - 0.00812 = 0.00479$ lb water per lb dry air.

Now let's determine relative humidity at the cooler outlet. First we must find P_{s2} from:

$$P_s = P_t\overline{SH}/(0.622 + \overline{SH}) = 30 \times 0.01291/(0.622 + 0.01291) = 0.6099\text{-in. Hg}$$

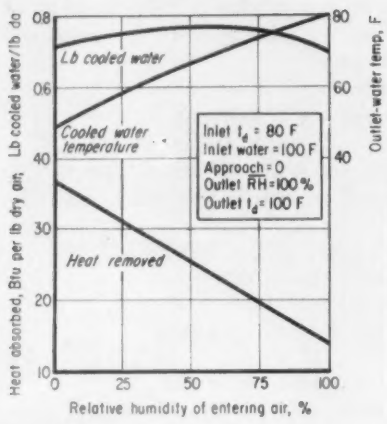
Substituting in:

$$\overline{RH}_2 = (\overline{SH}_2/0.622)\,(P_s/P_g) = (0.01291/0.622)\,[(30 - 0.61)/1.0321] = 0.591$$

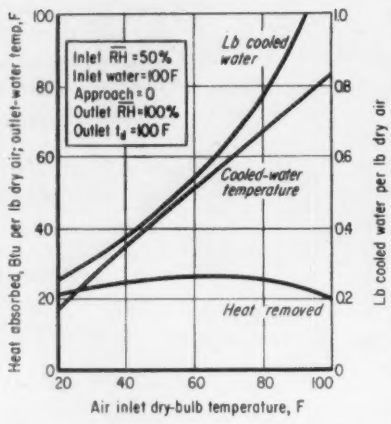
or 59.1% at the outlet.

Cooling tower, Fig. 3, acts as a device to transfer unavailable energy to the great natural sink—our atmosphere. More pointedly, the air is used to cool water that circulates through a plant to carry off unusable energy.

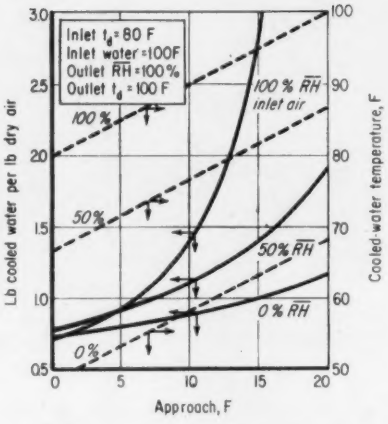
The water sprays into the top of the tower to fall in small droplets over "fill" material to the bottom of the


Heat absorbed, Btu per lb dry air; Lb cooled water/lb dry air
Outlet-water temp, F
Lb cooled water
Cooled water temperature
Heat removed
Inlet t_d = 80 F
Inlet water = 100 F
Approach = 0
Outlet $\overline{RH}$ = 100 %
Outlet t_d = 100 F
Relative humidity of entering air, %

4 Rising humidity ups water temperature and cuts heat removed from the water


Heat absorbed, Btu per lb dry air; outlet-water temp, F
Inlet $\overline{RH}$ = 50%
Inlet water = 100F
Approach = 0
Outlet $\overline{RH}$ = 100%
Outlet t_d = 100 F
Lb cooled water
Cooled-water temperature
Heat removed
Air inlet dry-bulb temperature, F

5 Rising air temperature raises water temperature with little change in Q



6 Rising approach makes water temperature go up, but cools more water flow

tower. Atmospheric air flows upward through the tower, against the current of the water. The water drops' large surface makes it easy to evaporate some water to mix with the air and so cool the remainder of the water.

Ideally the coolest and driest air meets the coolest water drops at the tower bottom and the water temperature equals wet-bulb temperature of the entering air-vapor mixture—that is, $t_b = t_{w1}$. It would take a very large tower to do this, so the nearness to the ideal for an actual tower is measured by the *approach* $= t_b - t_{w1}$. Useful output of the tower is the amount of cooling done on the circulating water w_w and measured by *cooling range* $= t_a - t_b$. The ideal tower would have a cooling range of $t_a - t_{w1}$. Note that *approach* + *cooling range* $= t_a - t_{w1}$.

Energy balance of the cooling tower accounts for: the dry air flowing through, vapor entering with the air, vapor leaving with the air, cooling water entering, cooling water leaving, and their respective enthalpies. We may write the balance as:

$$w_a H_{a1} + w_{v1} H_{v1} + w_{w1} H_{w1} = w_a H_{a2} + w_{v2} H_{v2} + w_{w2} H_{w2}$$

Dividing throughout by w_a, we can relate this equation to one lb of dry air:

$$H_{a1} + \overline{SH}_1 H_{v1} + (w_{w1}/w_a) H_{w1} = H_{a2} + \overline{SH}_2 H_{v2} + (w_{w2}/w_a) H_{w2}$$

Taking a mass balance about the tower:

$$(w_{w1}/w_a) + \overline{SH}_1 = (w_{w2}/w_a) + \overline{SH}_2$$

$$w_{w1}/w_a = \overline{SH}_2 - \overline{SH}_1 + (w_{w2}/w_a)$$

Substituting this value of w_{w1}/w_a in the energy balance and clearing we get:

$$\frac{w_{w2}}{w_a} = \frac{H_{a1} - H_{a2} + \overline{SH}_1 (H_{v1} - H_{w1}) - \overline{SH}_2 (H_{v2} - H_{w1})}{H_{w2} - H_{w1}}$$

Example, Fig. 3, lets us apply the above equations. Here we have air entering at 80-F dry bulb and 66.6-F wet bulb which is a relative humidity of 50.0%. Cooling water enters tower top at 100 F and leaves the bottom at 75 F. Air-vapor mixture leaves the tower at 95-F dry bulb and wet bulb of 93.6 F, which is a relative humidity of 95% (the ideal tower would have $t_{d2} = t_a$ and $\overline{RH}_2 = 100\%$). How much cooled water leaves the tower per lb of dry-air flow? How much hot water enters the tower per lb of dry air?

Tower cooling range = 100 – 75 = 25 F.

Tower approach = 75 – 66.6 = 8.4 F

$$P_{s1} = \overline{RH}_1 P_{g1} = 0.5 \times 0.5069 = 0.2535 \text{ psia}$$

$$\overline{SH}_1 = 0.622 P_{s1}/(P_t - P_{s1}) = 0.622 \times 0.2535/(14.7 - 0.2535) = 0.01092 \text{ lb vapor per lb dry air}$$

$$P_{s2} = \overline{RH}_2 P_{g2} = 0.95 \times 0.8513 = 0.8087 \text{ psia}$$

$$\overline{SH}_2 = 0.622 P_{s2}/(P_t - P_{s2}) = 0.622 \times 0.8087/(14.7 - 0.8087) = 0.03623 \text{ lb vapor per lb dry air}$$

With these factors figured we're ready to calculate water cooled per lb air:

$$\frac{0.24(95 - 80) + 0.01092(1060 + 0.45 \times 80 - 68) - 0.03623(1060 + 0.45 \times 95 - 68)}{75 - 100}$$

$= w_{w2}/w_a = 0.906$ lb cooled water per lb dry air

Then it follows that:

$$w_{w1}/w_a = (w_{w2}/w_a) + \overline{SH}_2 - \overline{SH}_1 = 0.909 + 0.0362 - 0.0109 = 0.9343 \text{ lb hot water per lb dry air}$$

Ideal-tower limits of performance are shown in Fig. 4, 5 and 6. These are all based on inlet-water temperature of 100 F, 100% outlet relative humidity and outlet dry-bulb temperature of 100 F. Boxes list fixed values.

In Fig. 4 we have additional constants: inlet dry-bulb of 80 F and zero approach. This graph shows what happens as the entering relative humidity varies from zero to 100%: Heat removed per lb of dry air drops inversely with rising humidity, which means the cooled-water temperature rises. Water cooled per lb of dry air varies through only a narrow range.

Heat removal becomes more limited with rising humidity because of the reduced opportunity to evaporate water into the air-vapor mixture flowing through the tower. Heat absorbed by the dry air stays practically constant over the range of humidity. Cooled-water temperature for the ideal tower equals the wet-bulb temperature of the entering air-vapor mixture.

Fig. 5 holds the entering relative humidity at 50%

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Coppus Turbines are built to customers' specifications, including API and NEMA standards. Sizes from 1 HP to 250 HP. All Coppus Products carry the same Blue Ribbon assurance of reliable performance. For further facts on turbines, send for new Catalog 200. COPPUS ENGINEERING CORPORATION, 172 Park Ave., Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

For more facts circle 290 on Reader Service card, p 117

Fast, intermittent trap action . . .

Nicholson weight-operated traps for gas, air, steam and gasoline service

This sectional illustration describes the fast, intermittent action of Nicholson weight-operated traps for pressures up to 1500 lbs. But don't let that float fool you. This trap is float-actuated, not float-operated as are other float-type traps. Here's how this exclusive Nicholson feature works.

When water enters the trap the float rises, eventually *actuating* the weight latch to release the counterweight, which then falls, lifting the discharge valve wide open . . . *instantaneously*. A link latch holds the valve open until discharging water lowers the float, *actuating* the rising counterweight to re-engage the weight latch. The discharge valve is then released by the link latch and closes *instantaneously*.

This rapid, intermittent opening and closing action is a feature you'll find *only* in Nicholson weight-operated traps, including models JR for pressures to 250 lbs., WO and B to 650 lbs., and C to 1500 lbs. Mail coupon for Catalog 500.

W. H. NICHOLSON and CO., 12 Oregon St., Wilkes-Barre, Pa.

Please send Catalog 500 describing Nicholson weight-operated traps for saturated or superheated steam, compressed air and gasoline, oil and gas service.

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Our 80th Year

Thermo refresher

Begins on page 146

and varies the dry-bulb temperature. Here the dry air's heat-absorbing capacity drops with rising inlet dry-bulb, but heat absorption involved in evaporating the water compensates, so total heat removed per lb of dry air varies relatively little. Increasing wet-bulb temperature that goes along with rising dry-bulb makes the cooled-water temperature rise with the dry-bulb. Note that even though dry-bulb rises to 100 F where the dry air can't absorb heat, evaporation theoretically can cool the water to 83.2 F. The diminished cooling range with rising dry-bulb means that more lb of water can be cooled per lb of dry air.

In Fig. 6 we study the effect of approach on the water-air ratio and the cooled-water temperature for 0, 50 and 100% entering relative humidity. As the approach rises, cooled-water temperature also rises to shrink the cooling range at all humidity levels. Because of the diminishing cooling range, water cooled per lb of dry air rises with the approach, at varying rates for the different humidity levels.

A last word of caution: don't confuse these curves with actual cooling-tower performance. These only define limits in which cooling towers can work under ideal conditions.

This part ends the Thermo Refresher *series which had its initial article in the August 1956 issue of* POWER. *The series is being adapted to book form to be published by the McGraw-Hill Book Co, and the book should be available in the fall of 1962. Tentative title:* **Thermodynamics of Energy Systems.**

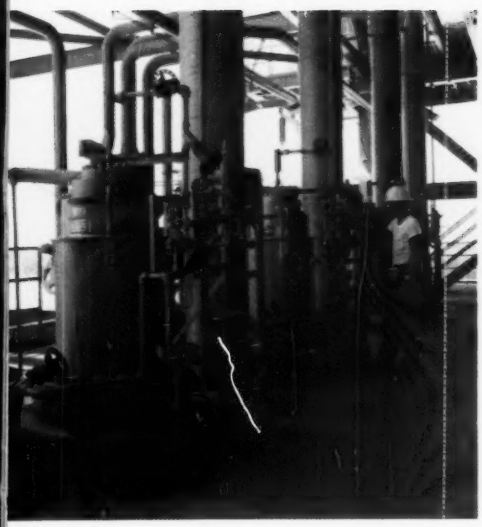
An unusual electric-power distribution station was recently dedicated in Los Angeles by the Dept of Water and Power. It is located twenty feet below ground in the heart of the downtown textile area. The street-level space on top of the facility is used as a parking lot—$32,700 a year income from the parking lease more than offsets cost of placing the $1,377,000 station underground.

For more facts circle 291 on Reader Service card, p 117

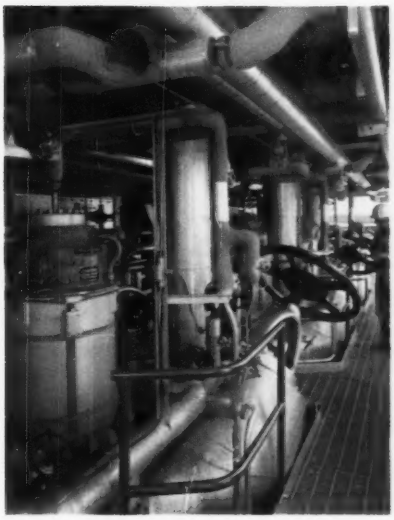
Circle 292 on Reader Service card, p 117 ➤

MAINTENANCE?
FORGET IT!

Westinghouse canned motor pumps give you more than zero leakage. Operating people are finding these pumps truly economical in controlled circulation boiler systems. No seal maintenance or external bearing lubrication is necessary. They can withstand full temperature and pressure at hot standby conditions. No adjustments are necessary. They can be started and stopped at any time at full pressure and temperature. It will pay *you* to investigate the economics of these unique pumps. Call or write for complete engineering and performance data.

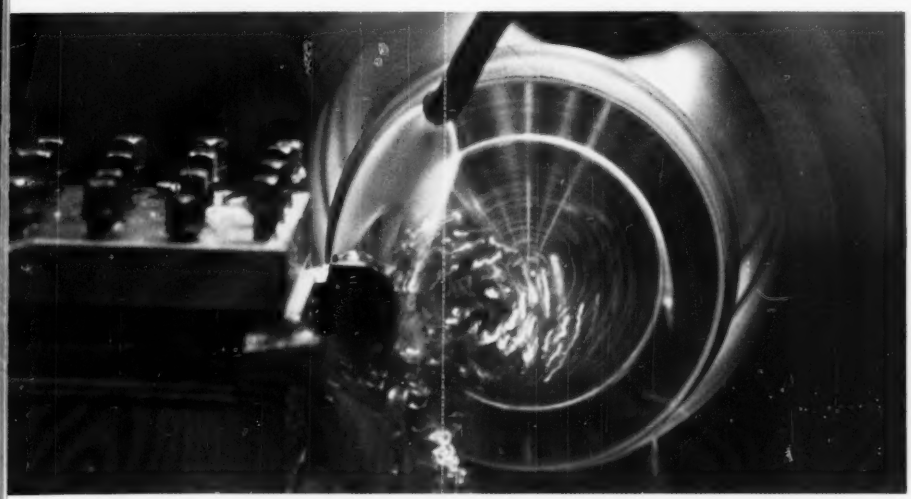


Florida Power & Light Company has eight of these Westinghouse canned pumps in operation at the Port Everglades Station.



Three canned motor pumps are installed in the H. B. Robinson Station of the Carolina Power & Light Company.

Successful operation is reported for these three Westinghouse pumps at the Yorktown Station of Virginia Electric Power Company.

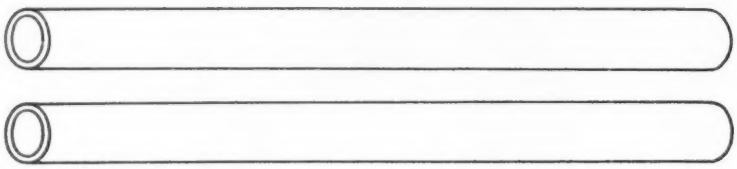


Modern production and testing equipment make Westinghouse Atomic Equipment Department the most complete facility of its type in the world. Controlled circulation boiler pumps are available in many head and flow combinations for high temperature, high pressure applications.

JI 58006

Westinghouse

What's so different about stainless tubing?



What's so different about stainless tubing? Take two stainless tubes made by different manufacturers to the same specification. Put them in a heat exchanger. In service, they may react differently.

One tube successfully resists corrosion, the other doesn't. One holds up under pressure at operating temperature, the other fails. Why?

Basically, the difference in stainless tubing starts with who makes it.

One manufacturer maintains quality controls from melting of steel to finished tube. Another may not. One tube maker will carefully match stainless grades and properties to be sure the tube is *Job-Matched* to the user's specific requirements. Another won't. The differences go on and on.

The surest way to know how the differences in stainless tubing will benefit you is to know the manufacturer and what he can do. Then, specify his product by name when you order direct or through your Steel Service Center. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

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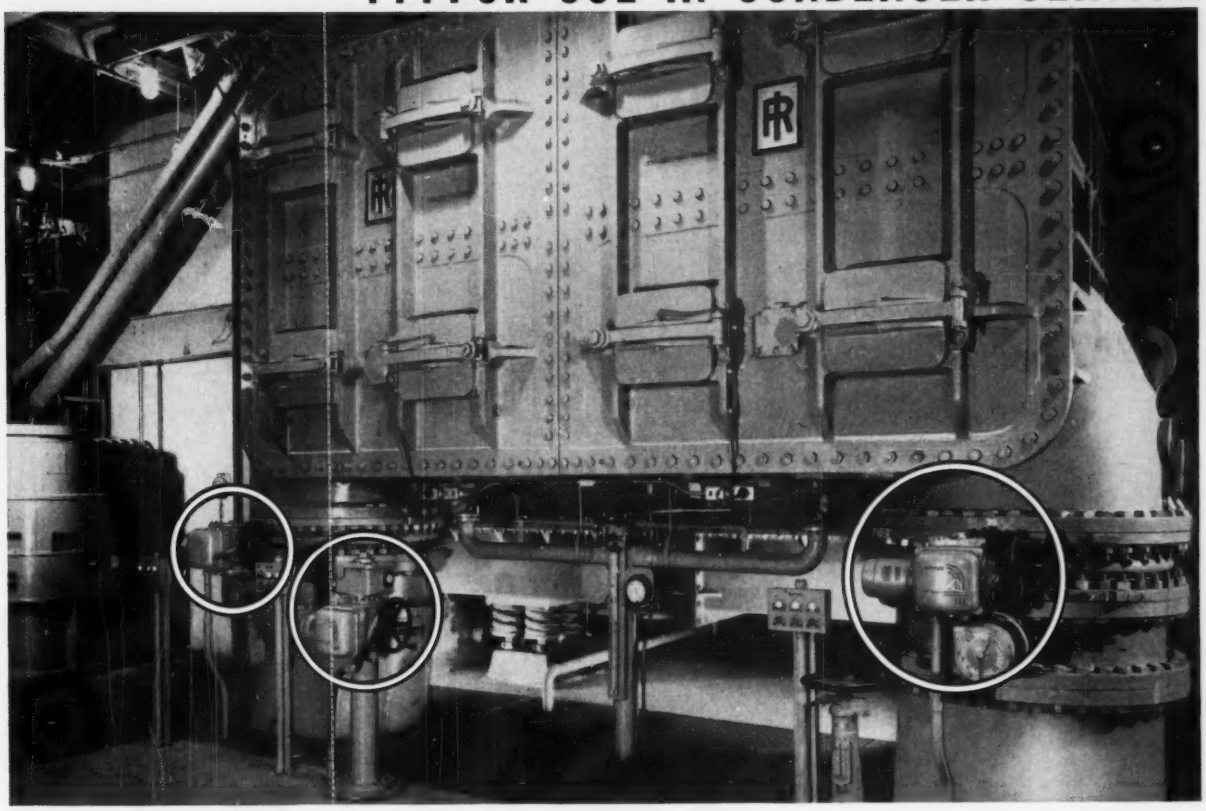
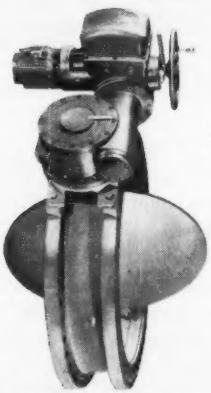


...on Three [IR] Rectangular Condensers

...in large West Coast Steam Plant



Send for Bulletin #15-60, and please use your Business Letterhead when requesting a copy.

Above is shown one of the three Ingersoll-Rand space-saving Rectangular Condensers which serve the three 100,000 k.w. Generating Units in a large, well-known West Coast Steam Plant. Each Condenser contains 50,000 square feet of surface. Six I-R vertical pumps push nearly 270,000 gallons of cooling water per minute through the LimiTorque operated Butterfly Valves and the condenser tubes. The condensate is handled by six other I-R vertical pumps.

It is highly significant that LimiTorque Valve Operators are used in practically every Central Station and Large Industrial Power Plant built during the last twenty-five years—because of their absolute accuracy and reliability.

Where automatic, remote Valve Operation is required, LimiTorque will provide rapid, precise, safe and dependable control, under all operating conditions . . . and, remember too, LimiTorque can be field-mounted on most all existing valves. For specific applications, consult your Valve Manufacturer or nearest LimiTorque Sales-Engineering Office.

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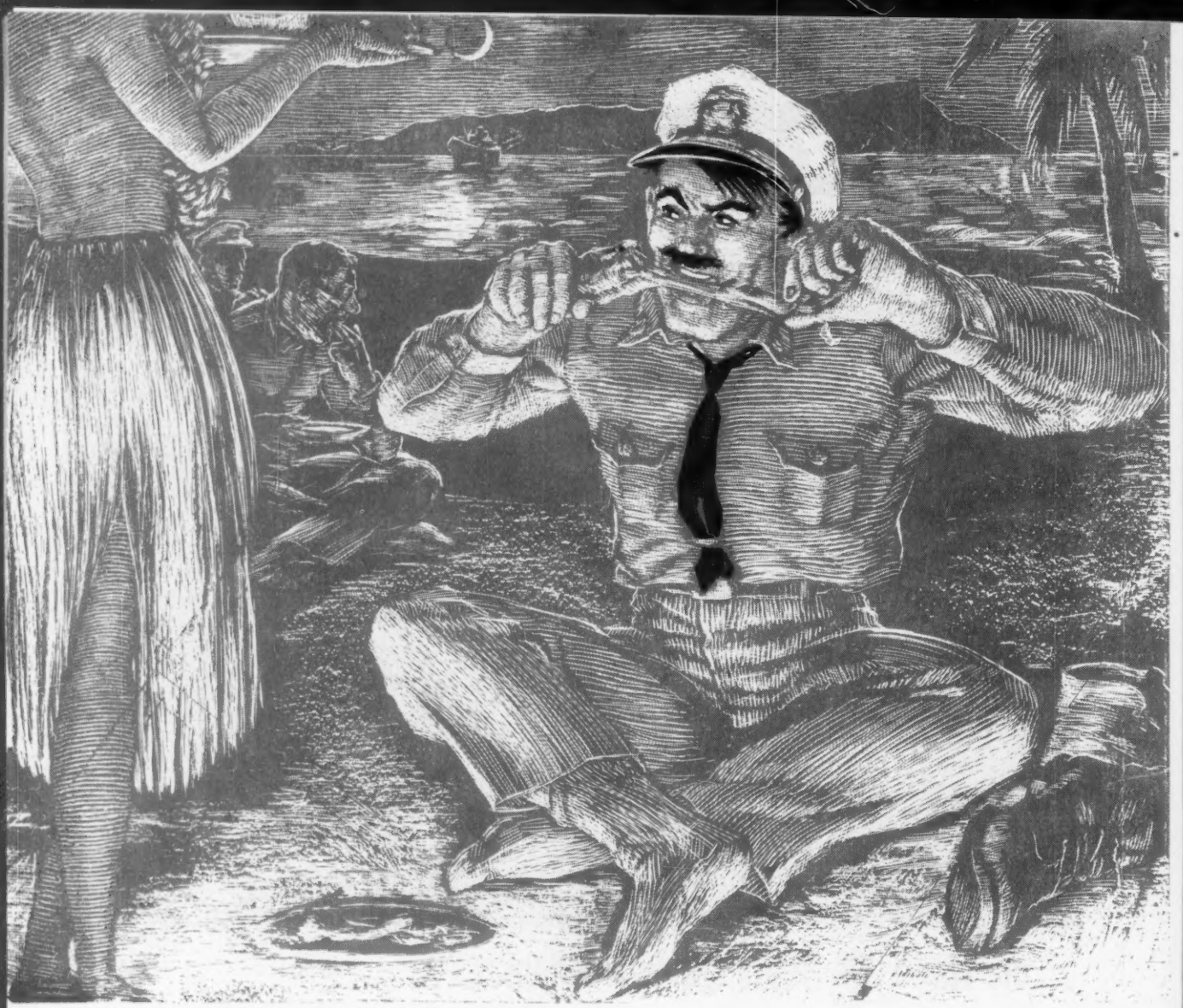


An hour after straightening out the engine, Marmy and the navy officers sat down on Waikiki Beach under moonlit tropic skies

Marmy's whirling dervishes

Zamboanga is a tiny dot on the southern tip of Mboanga, one of the many tropical islands that make up the Philippines group. In peacetime it's a stop for an occasional dry-cargo steamer loading copra. You and I hardly know it exists—and we care less.

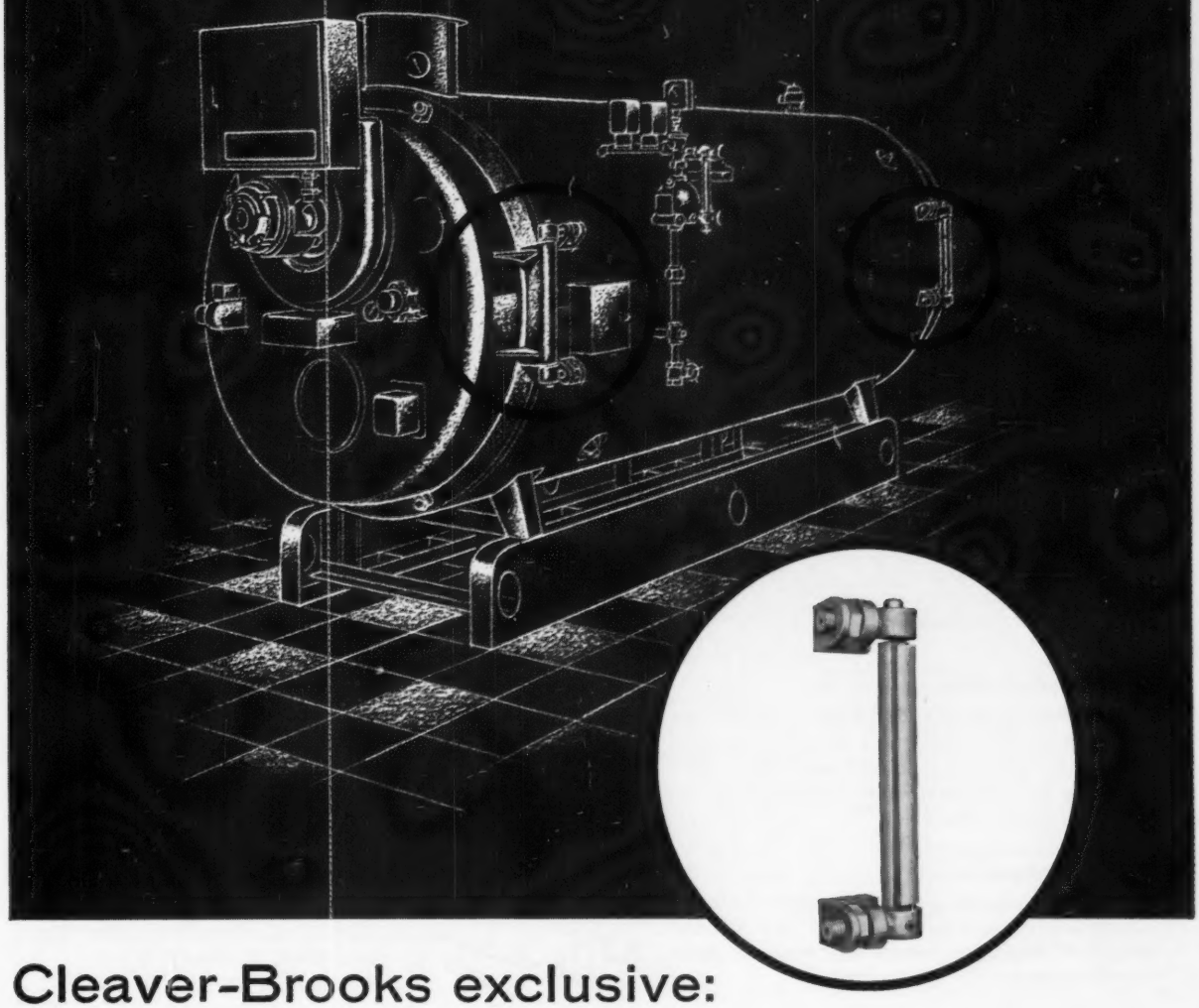
But on a torrid December morning in 1944, Engineering Officer Russel Quimby of the *U.S.S. Iroquois* had Zamboanga on his mind. He thought of little else, and for good reason. He and his engine-room crew were sloshing around in knee-deep water, trying desperately to coax the big triple-expansion steam engine into staying alive until the ship was safely tied up at the Zamboanga pier.

It had all happened early that morning while they were escorting a convoy across the Sulu sea. A depth charge intended for a Japanese submarine that had just sent a tanker down to Davy Jones' locker had shaken the *Iroquois* violently. Her 12-in. condenser-discharge line was split, and sea water poured from it into the engine room faster than her bilge and ballast pumps could shove it overboard again. Luckily, the watertight door kept the fire room dry. But two hours before the *Iroquois* reached the flimsy wooden dock, her main bearings and cranks were churning in sea water. Quimby was mighty happy to tie up.

Once they had tied safely alongside, the large overboard gate valve was finally closed and the engine room pumped dry. Two days later the main condenser discharge had been repaired after a fashion, and the *Iroquois* received orders to steam out to sea to swing compass, then escort a convoy bound for Pearl Harbor.

The chief started warming up the main engine as usual, by passing steam through her cylinders for an hour or so. Then he tried to set the engine rocking back and forth. But instead of rocking with a few lb of steam, the crank wouldn't even budge until she got over 100 psi. The bearings were apparently frozen because the engine had been shut down without being oiled—after running for hours

Engineering Excellence stands out...



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Hinges for boiler heads are not alike. Some serve no useful purpose — they're merely window dressing.

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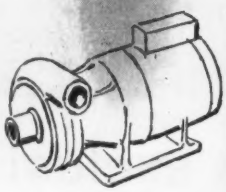

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Marmaduke

Begins on page 154

in sea water.

Quimby was a diesel operator ashore. Under hectic wartime conditions he suddenly found himself aboard a steam ship. Being a frugal man by nature, he just couldn't see pouring all that lubricating oil through the main engine bearings only once, then wasting it to the bilges. If you examined his engine logbook you'd find only quarts of oil used daily where it should have been gallons.

As the main engine answered the first bell, its din and clatter were frightening. Then on the first full-ahead bell, the h-p cylinder started knocking so badly that the gaping natives on the wooden pier went scurrying back to the protection of a coconut grove. The captain hurriedly called down from the bridge to tell the engineering officer he'd give him time to find the trouble as they swung at anchor before joining the convoy.

Soon as the anchor was dropped, the engine-room gang opened up their h-p cylinder. They found the piston loose on the rod, with the nut backed off to the cotter pin. That allowed about a quarter-inch of play. They quickly drove the nut down tight against the piston, replaced and bolted down the cylinder cover.

"That'll damn well stop the knocking," grunted the chief with great satisfaction, as he climbed the engine-room ladder to report.

At midnight the *Iroquois* lifted anchor and steamed to her rendezvous. The clatter and screeching of that main engine was deafening, but at least the cylinder didn't knock—at first. But as the throttle was opened wider and the engine exceeded 140 rpm, sledge-hammer blows again started in the h-p cylinder. Those knocks, blended with the weird noises of the bearings, sounded like a band of whirling dervishes suddenly gone mad, banging away at giant gongs for good measure.

The fleet commander gave the *Iroquois* permission to drop below 140 rpm. Again, the knocking stopped completely, but the screeching main bearings, cranks and eccentric brasses sounded as bad as ever.

The triple-expansion engine was a

(Advertisement)

Why a Steam Trap Has to Handle "Air"

Low temperatures and corrosion of equipment are often evidence of inadequate trap air venting capacity

Air, with its load of oxygen and carbon dioxide, has an unwholesome habit of interfering with the efficiency of steam heated units. If steam were always free of these undesirable companions, things would be a lot simpler for men-who-operate-plants. Because it isn't, three unhappy situations frequently occur:

1. ***Operating temperatures are subnormal.*** This is a two-part problem. First, an air-steam mixture has a lower temperature than pure steam at the same pressure—see Table A. Secondly, air can "plate out" on heat transfer surfaces as shown in Figure 1. Under some conditions, such an air film will knock down heat transfer efficiency by as much as 50%.

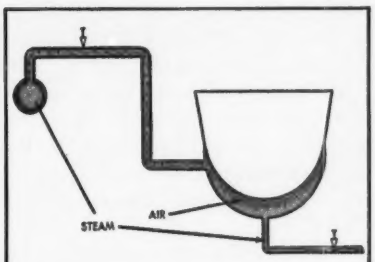


Fig. 1. *How air can "plate out" on heat transfer surfaces. This "insulation" drastically reduces heat transfer efficiency. Armstrong trap operation creates turbulence in the equipment that prevents this.*

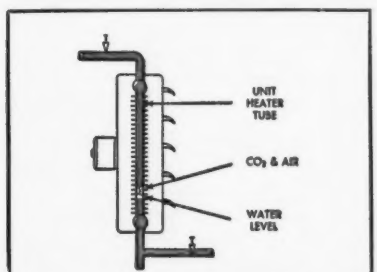


Fig. 2. *Corrosion occurs when units are not kept continuously free of both condensate and air. Armstrong traps discharge both,* at steam temperature, *as fast as they accumulate.*

2. ***Corrosion rears its ugly head.*** Oxygen and carbon dioxide are real trouble-makers. CO_2 gas goes into solution in condensate, forms carbonic acid and chews away at vulnerable metal sections. O_2 aggravates the situation. See Figure 2.

TABLE A—How air reduces steam temperature.

Gauge Pressure	Temp. of Steam with No Air Present	Temp. of Steam Mixed With Various Amounts of Air (% Air by Volume)	
		10%	30%
10.3	240.1	234.3	220.9
25.3	267.3	261.0	246.4
50.3	298.0	291.0	275.1
75.3	320.3	312.9	295.9
100.3	338.1	330.3	312.4

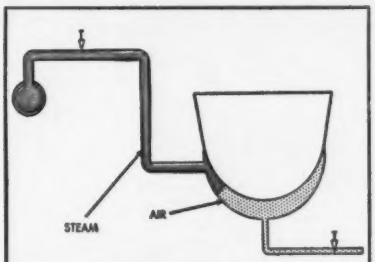


Fig. 3. *When steam is turned on, it takes a trap with extra air venting capacity to provide fast heat-up.*

3. ***Heat-up is slow as a snail.*** Air has a picnic in units that are shut off periodically. Figure 3 pictures the problem. Lines and equipment literally fill up with air. When the steam is turned on it can get in only as fast as the air gets out.

Enter Steam Traps

Curing these steam system ailments involves an operation sometimes called a "trap transplant." It consists of removing traps that don't get the air out and replacing them with traps that do.

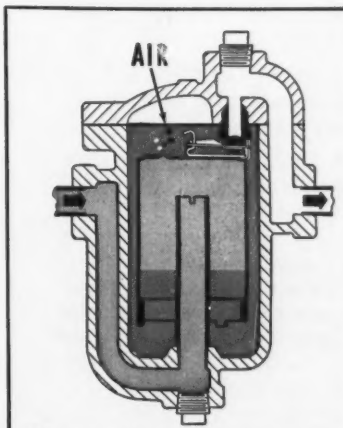
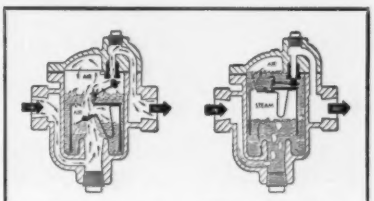


Fig. 4. *Air entering an Armstrong trap passes through the bucket vent and accumulates in the top of trap. When trap opens, air is discharged along with condensate.*

Figure 4 shows how an Armstrong inverted bucket trap continuously vents air. What the picture doesn't show is a built-in plus-value of this trap's design. An Armstrong trap opens suddenly, creating a momentary pressure drop and turbulence in the unit being drained. This breaks up air films and "pumps" air down to the trap so it can be vented.

The vents in standard Armstrong trap buckets will pass all the air normally encountered. In special cases, such as paper machine dryers, the vents are correctly sized larger at the factory to meet the requirement.



Thermostatic vent open. *Thermostatic vent closed.*

Fig. 5. *Open float with thermostatic vent for off-and-on units. When trap is cold, vent is open, permitting air to blow through when steam is turned on. When steam reaches trap, heat closes thermostatic vent. Then, regular bucket vent handles all air coming in with steam.*

Open Float with Thermostatic Vent

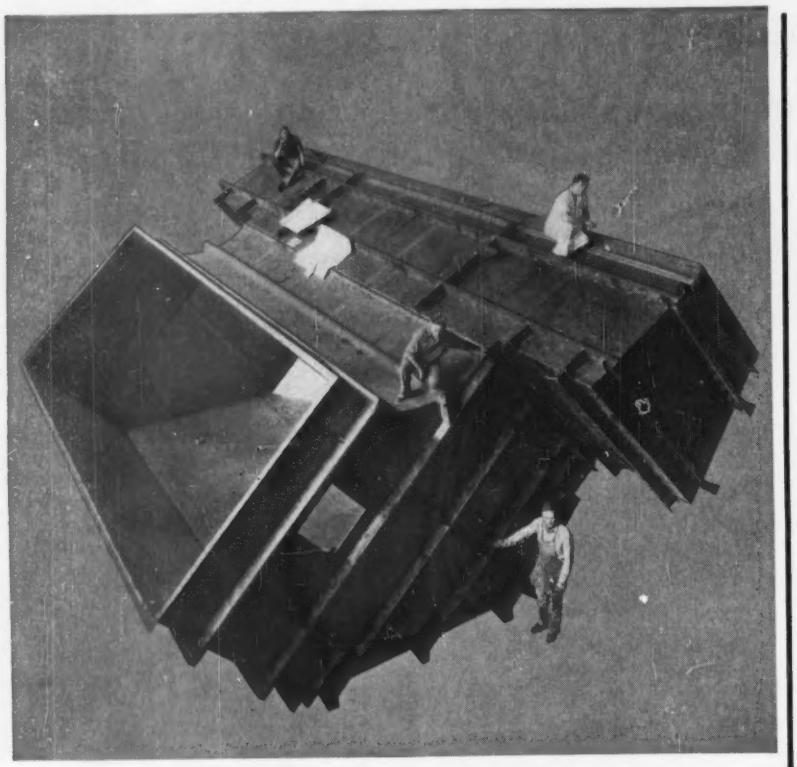
Super air-venting capacity is a must for fast heat-up of low pressure unit heaters, heating coils, steam headers and other units that are on-and-off. Figure 5 shows how the Armstrong open-float-with-thermostatic-vent trap takes care of this.

* * *

The 44-page Armstrong steam trap book covers other features of the Armstrong trap as well as its excellent air handling characteristics. This catalog also discusses trap selection, installation and maintenance. Your local Armstrong Representative or Distributor will be glad to give you a copy. Call him, or write Armstrong Machine Works, 8125 Maple Street, Three Rivers, Michigan.

ARMSTRONG STEAM TRAPS

See Our Catalog in Sweet's Plant Engineering File



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Marmaduke

Begins on page 154

2800-hp job turning at 180 rpm. The *Iroquois* had been built as a British corvette, with a top speed of about 17 knots under ideal conditions. She had been badly damaged and partly sunk, then salvaged and rebuilt at an island base and hurriedly pressed into service by the navy.

At Pearl Harbor the navy machinists came aboard to overhaul her main engine. Opening the h-p cylinder, they were amazed to find the piston-rod nut tight. They refitted the piston rings and closed the cylinder. Every bearing and eccentric was badly wiped or burned out. The reversing-gear brasses were so severely scored there were tiny balls of loose brass in the bearings. How the ship ever crossed so many miles of submarine-infested Pacific in that condition was a mystery to everyone. But no one could understand why her h-p cylinder should have knocked so badly.

The navy machinists stripped down the h-p-cylinder valve gear. They remachined the piston rod for a tight fit into the piston boss. The top and bottom bearings were so hopelessly wiped that they had to be remetaled. The top end pins were remachined. Then the crank bearing was honed by hand. But the rust and corrosion marks were embedded so deeply into the steel where the salt water had lain in the oil grooves that they would not come out.

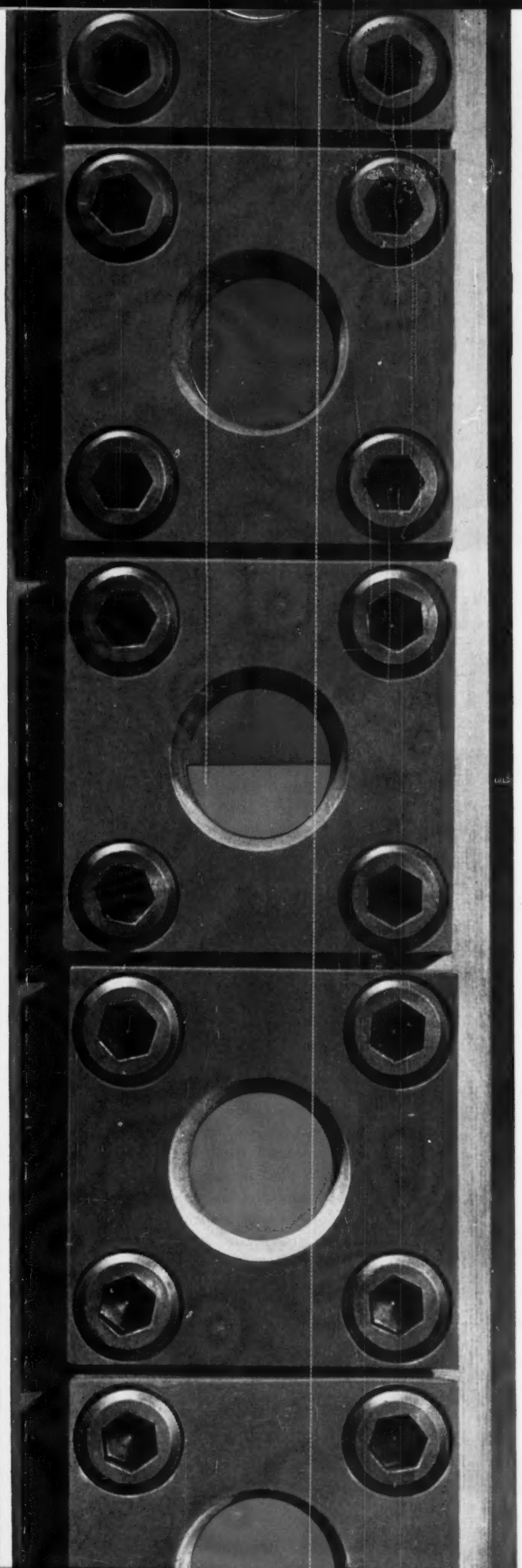
As an added precaution to stop the knock, they gave the h-p valve earlier lead on the up-stroke by placing a shim under her eccentric-strap connecting rod. Then the whole engine was realigned.

After three days of around-the-clock work the job was complete, and the *Iroquois* was ready for a test run. Some top navy brass from the shipyard was aboard. Steaming along at half speed, the engine was quiet as a gyro compass. But soon as they opened her up to 140 rpm, loud metallic knocks erupted from the h-p cylinder as violently as before.

At the officers' club that evening there was a perplexed group of navy brass. The story of the knocking pis-

For more facts circle 298 on Reader Service card, p 117

circle 299 on Reader Service card, p 117 ➤



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Here's Diamond's *newest* multi-port bi-color water gauge. It's the DURA-PORT . . . proved superior by twelve months' intensive field testing by 11 leading utilities.* Designed specifically for operating pressures from 1051 to 3000 psi, the DURA-PORT assures dependable, easy-to-see water level readings with up to 80% less maintenance. Here's why:

1. New port sealing design . . . clamping load on glass is limited to that imposed by gasketing compression . . . all but eliminates glass breakage caused by clamping overload . . . slashes port replacement expense . . . (no glass breakage experienced with test gauges to date).

2. New gasketing arrangement . . . provides ample resiliency for continuous seal under expansion . . . no torque wrench needed!

3. Fewer coverplate screws . . . four socket head cap screws — tightened with standard hex wrench — firmly secure individual ports . . . cut port replacement time by more than one half.

4. 1" dia. ports . . . largest on any gauge designed for high pressure applications. Combined with new high-intensity illuminator, larger ports assure brighter, more distinct water level indication over longer distances . . . far better than any design previously available.

5. Two vision lengths . . . 18" (7 ports) and 12¼" (5 ports).

6. Temperature equalizing design . . . recommended for pressures 2000 psi and over; reduces error caused by temperature differentials by as much as 75%.

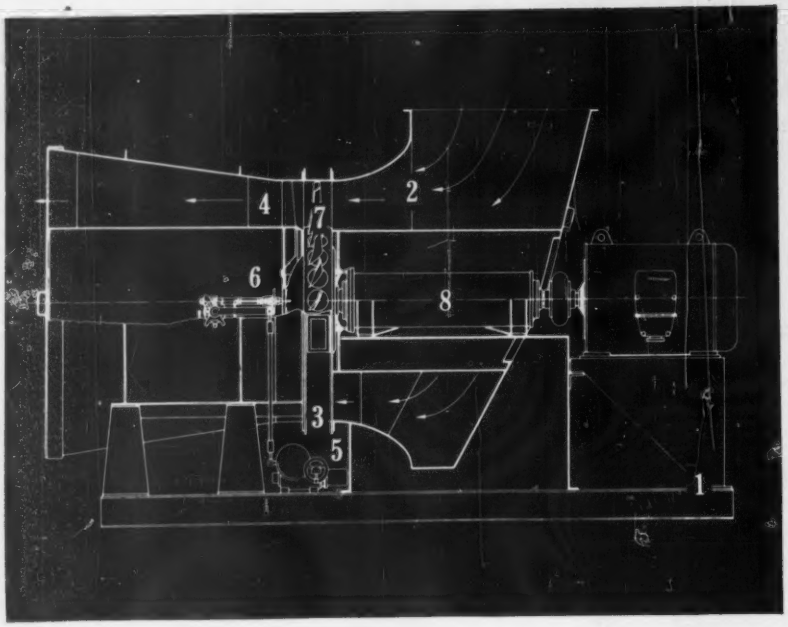
7. Choice of four viewing hoods . . . 90° reflector, open front stub, direct reading or direct reading with exclusive new wide-angle vision.

All Diamond gauges are steam tested and when they leave our factory are ready for operation after normal warm up procedure.

Bulletin DP-2607 has complete details... call write or wire for your copy... today.

*names and test results on request

DIAMOND POWER SPECIALTY CORPORATION
LANCASTER, OHIO
Diamond Specialty Limited • Windsor, Ontario



VARIAX...The busiest axial flow fan in the industrial countries of the world

1 *Base frame with motor support.*
2 *Inlet box and inlet cone.*
3 *Housing.*
4 *Diffuser with fixed guide vanes.*
5 *Servomotor.*
6 *Blade adjustment mechanism.*
7 *Fanwheel.*
8 *Main bearing assembly.*

You name the country and we'll name the Variax installations. In utilities, industrial plants, government projects – wherever space is at a premium and a fan *fully controllable during operation* is needed – you'll find a Variax model at work. Capacity range is from 50,000 to 1,100,000 cu. ft/min. Designed in accordance with the latest aerodynamic principles, the Variax blade angie can be varied during operation to give optimum results and minimize losses. The short overall length of the Variax fan facilitates its easy, straight-forward incorporation in boiler plants and other installations. The Variax is ideal for parallel working. Parts and service facilities are maintained for this American fan and a full engineering staff can answer all your questions. Please write for full literature and the booklet "Axial Flow Fans for Boiler Draught Requirements" to:

NOVENCO INC.
40 Exchange Pl., New York, N.Y.
Tel. HA 2-5470

For more facts circle 301 on Reader Service card, p 117

Marmaduke

Begins on page 154

ton was told again and again. The *Iroquois* was slated for a convoy leaving in 24 hours. If she wasn't ready someone had a lot of explaining to do to the Admiral. After all, why should a steam-cylinder knock be so hard to find?

"BILGEWATER on loose pistons, loose nuts and on loose marine engineers with loose knibbling pins in their loose heads," suddenly roared a foghorn voice.

Conversation stopped abruptly as all heads turned in the direction of that blast. The voice belonged to a tall, muscular navy commander sitting at the next table. He was nursing a bottle of Sandpaper Gin. A long cigar extruded from beneath his steel-brush mustache.

"I'm Marmaduke Surfaceblow, engineering officer of the *U.S.S. Lejeune*," the abrasive gentleman quickly enlightened his dumbfounded audience. "You guys have been holding Operation Jawbone on a knocking h-p cylinder all evening. Pipe me aboard and if I don't unravel that Chinese puzzle in less time than it takes a sailor to go broke on his first liberty, I'll blow all you masterminds to a native chow over on Waikiki Beach tonight. But if I do," he bargained, "you finance the blowout — and I want two cases of Sandpaper Gin aboard my ship before I shove off for New Guinea at 0600 tomorrow."

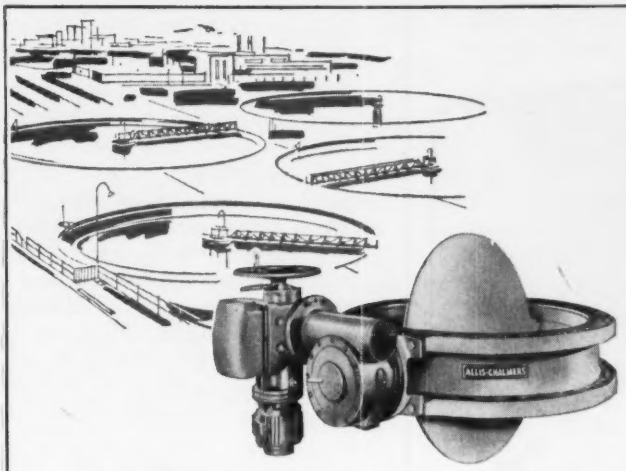
For a minute the quiet was deafening. "What can we lose but two cases of gin and the cost of a native feast?" finally erupted good-natured Capt George Denig, who was in charge of yard repairs. "Anchors away!"

Aboard the *Iroquois*, Marmaduke was surrounded by the navy repair officers and the ship's engineers. The h-p cylinder was already open with its cover hanging from a chain fall.

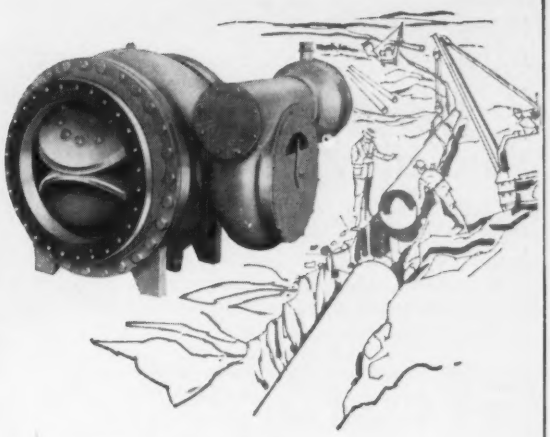
"Just gimme a light," roared Marmy, yanking the flashlight out of the chief's hip pocket. He focused the beam on the cylinder top and carefully started examining its surface. Suddenly the beam stopped, zeroed in on a dowel screw.

"What's this?" rasped Marmaduke, bending down for a closer examination. The dowel screw split the liner's

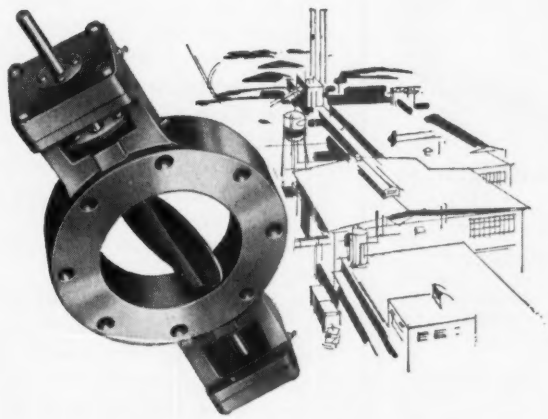
ALLIS-CHALMERS



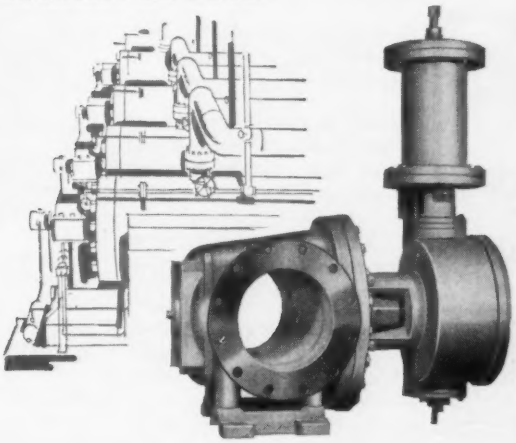
BUTTERFLY VALVES — For liquids or gases — uniform control in all positions, fast positive regulation and closure, minimum pressure drop. Compact and lightweight. Sizes from 1 in.



BALL VALVES — Easy manual shutoff under adverse conditions, and up to 150 psi. Slight wedging action gives unusually drop-tight closure. Sizes: 12 to 48 in.



WAFER VALVES — A new design of butterfly valves with space-saving flexibility, suited to most any type of operation. Sizes from 3 to 36 in., including high-pressure types.



ROTOVALVE — A cone valve suited to virtually any type of operation or location. Offers the least pressure loss, greatest initial shutoff, controlled closing time, positive seating.

Now: for power plants, sewage and water works —

a full line of rotary valves

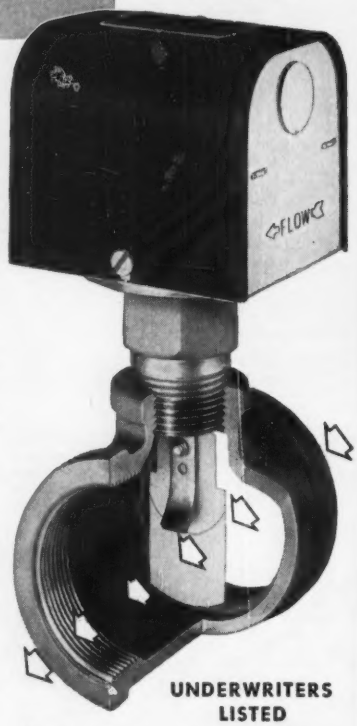
Serving you even better through a broader line—Allis-Chalmers offers the finest in butterfly, ball and cone valves for industrial applications, power plants, sewage and water works. Also available are complete valving systems in standardized "packages" that provide *remote, telemetered control of valve operation.* These additions further round out Allis-Chalmers line that includes Angle, Needle, Relief valves, sleeve-type valves and accumulator systems. *For details, contact your Allis-Chalmers valve representative or write* **Allis-Chalmers,** *Milwaukee 1, Wisconsin.* Rotovalve is an Allis-Chalmers trademark.

A-1381

For more facts circle 302 on Reader Service card, p 117

McDONNELL
Flow Switches

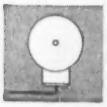
FS4 Series Flow Switch shown mounted in a 2 inch Tee



Here's what they do!

What you see here is a compact, well-built switch that makes or breaks a circuit (as required) when liquid flows or stops flowing. It's an economical and positive way to start or stop anything electrically operated. Just to highlight a few uses:

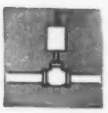
to actuate a signal light—signal an attendant to make the right moves in operating valves, pumps and the like—signal him when flow stops in a water cooled compressor, water cooled bearing and so on.



to sound an alarm—when flow stops in a process system or in any water cooled devices.

to start or stop motors—start pumps in sequence in multiple stage flow systems; start standby pumps; stop automatically controlled units if cooling water system fails; stop compressors in cooling systems when flow stops.

to start or stop automatic burners—start a booster heater when water draw occurs, stop burner if flow is improperly retarded; make sure of circulation in a boiler before burner is permitted to start.



to actuate metering device—open valve in chemical feeder line; start mixing in secondary line whenever flow starts in primary line.

UNDERWRITERS LISTED

Positive snap action switch. Easy to install and wire. Segmented paddle fits any pipe from 1" through 3". Unit shown handles pressures to 100 psi, temperatures to 300° F., in these types:

FS4-3—SPDT switch. Opens and closes two separate circuits with flow; closes and opens same two circuits with no flow.

FS4—Closes with flow; opens with no flow.

FS4R—Opens with flow; closes with no flow.

NOTE: Model E-2 available for larger pipes, pressures to 150 psi.

McDONNELL & MILLER, *Inc.*
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For more facts circle 303 on Reader Service card, p 117

Marmaduke

Begins on page 154

top and the engine casting frame. "Gimme a screwdriver," he barked. "What in hell's a dowel screw doing here in the first place?" There was no answer, but there were plenty of wrinkled brows, as if some great discovery had been made—but no one seemed to know exactly what.

Handed the screwdriver, Marmaduke went to work. "Just as I thought," he barked when he found the screw loose. Then he quickly glanced at the underside of the suspended cylinder head.

"Why is the inside half of this cylinder gasket that's opposite the liner pounded to nothing?" he growled, "and why is the end of this cylinder liner so shiny?" Before his perplexed audience could answer, he blasted, "only a loose liner would chew the gasket to shreds and pound the cylinder head so shiny."

"Say, Chief," gurgled Marmy without looking up, "place a few strips of lead wire around this liner's top and drop the cover and bolt her down with a couple of nuts. I want to see what happens."

The navy brass caught on; everyone seemed to break into conversation at once. Quimby rushed back from the storeroom and was placing four pieces of 0.060-in. dia lead wire about 90 deg apart around the liner as instructed. The first assistant engineer was already lowering the cylinder head.

Soon as the cover was tightened, then raised, Marmy picked up the pieces of squashed lead and squinted at them. "Here's your answer!" he shouted. "These leads are about forty-thousandths thicker where they rested on the liner than over the cylinder block. The answer's simple. The machinist who fitted this liner evidently took off too much metal, so he thought he'd hold down the liner with a dowel screw and cover up his mistake—ha!"

"Just a minute, Mr Surfaceblow," piped up Capt Denig. "If that liner is loose, why does she knock only when the engine gets up to 140 rpm?"

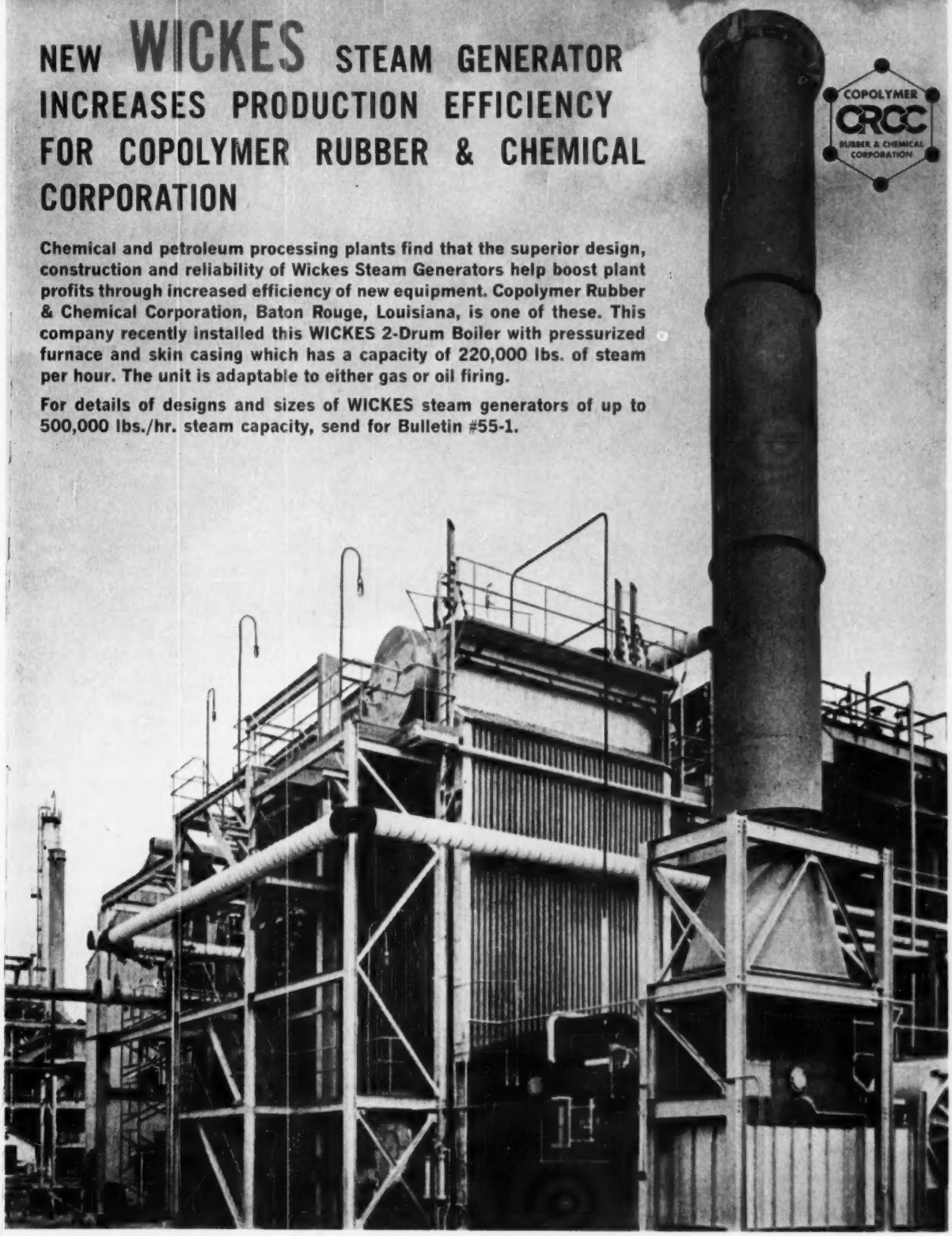
"Because," roared Marmaduke in his foghorn voice, "she has enough press fit to retain her at temperatures

NEW WICKES STEAM GENERATOR INCREASES PRODUCTION EFFICIENCY FOR COPOLYMER RUBBER & CHEMICAL CORPORATION

Chemical and petroleum processing plants find that the superior design, construction and reliability of Wickes Steam Generators help boost plant profits through increased efficiency of new equipment. Copolymer Rubber & Chemical Corporation, Baton Rouge, Louisiana, is one of these. This company recently installed this WICKES 2-Drum Boiler with pressurized furnace and skin casing which has a capacity of 220,000 lbs. of steam per hour. The unit is adaptable to either gas or oil firing.

For details of designs and sizes of WICKES steam generators of up to 500,000 lbs./hr. steam capacity, send for Bulletin #55-1.

COPOLYMER CRCC RUBBER & CHEMICAL CORPORATION



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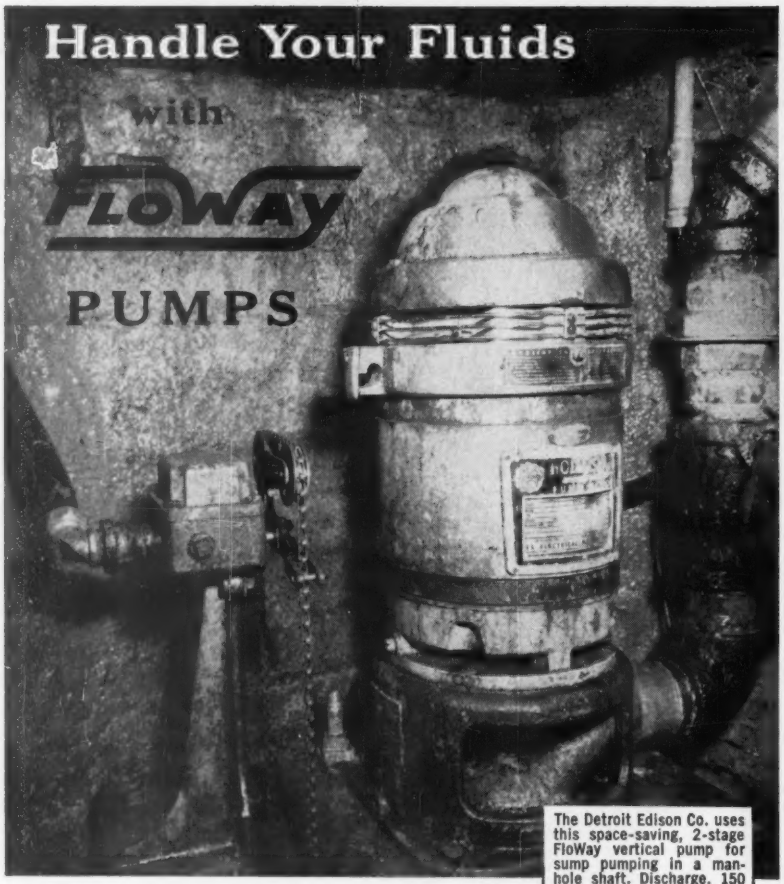

The Detroit Edison Co. uses this space-saving, 2-stage FloWay vertical pump for sump pumping in a manhole shaft. Discharge, 150 gpm at 90′ tdh with 5 hp, 3600 rpm motor.

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U. S. Steel · Union Carbide · Detroit Edison · Chas. Pfizer
General Electric · Pan American · Premier Oil
Colorado Springs... and many others

Job Tailored Pumps

FloWay vertical and submersible pumps today handle just about everything fluid, from water for cities and cooling towers, to highly corrosive and volatile chemicals. Wide selection of components – heads, column assemblies, packing boxes, suction cases, impellers – enables us to "custom make" pumps suited to your problem... at competitive prices. Cast iron, bronze, stainless steel, special alloys, etc. are used, as required.

Submersibles and Verticals

Submersibles from 100 to 4000 gpm, 0-1000 psi, 1750 and 3600 rpm, for wells 8" and larger. Verticals from 15 to 5000 gpm, 0-1000 psi, 800-3600 rpm. Both types comply with AWWA and Hydraulic Institute specifications and are approved by Corps of Engineers for aircraft fueling.

Bring Your Pump Problems to Us

In the field and in the factory your problems get personal attention from our closely-knit staff. Thirty years' designing and manufacturing experience – completely modern facilities. Literature and estimates without obligation. Wire or write us today for name of nearest representative. Fiese & Firstenberger Mfg., Inc., P.O. Box 164, 2494 Railroad Ave., Fresno, Calif.

1

FLOWAY Pumps

30 YEARS OF PUMP RESEARCH 30 QUALITY

Marmaduke

Begins on page 154

corresponding to less than 140 rpm —but above that the liner gets loose and reciprocates about forty-thousandths, plus the 1/16-in. thickness of the gasket, with each piston stroke."

"He's right—he's absolutely, completely and unequivocably right," yelled Captain Denig enthusiastically. "Jack," he addressed a commander, "have the shop make a metal ring to equal the difference shown in these leads and place it on the liner's end. Then have a new gasket made for the cylinder head and close her up."

An hour later at the High Talking Chief's Long House, the dozen yard officers and Marmaduke sat on beautiful Waikiki beach under moonlit tropic skies. The tantalizing aroma of fully dressed barbecued pig, baking underground with heated rocks, permeated the perfumed air.

Hip-swinging girls wearing grass skirts, leis around their ample bosom and a stick of red hibiscus over their left ear, served the men rum concoctions from bamboo containers playfully labeled Missionary's Downfall, Cobra's Fang and The Vicious Virgin. Soon wooden platters of pork were set before each guest—no knives or forks, of course. They dug in with their bare hands, licked their finger tips. They ate poi, and laulau wrapped in ti leaf. The party lasted until daybreak.

But in spite of the celebration, Marmaduke walked up the gangplank of the *U.S.S. Lejeune* under his own power and on time, before she sailed next morning. And what was more important to the war effort — the *U.S.S. Iroquois* joined her convoy, right on schedule.—STEVE ELONKA

Marmy's mail

DEAR MR FRASER . . .

of N.S.W., Kogarah, Australia: Your letter in Dec 1960 POWER is interesting. But if you had worked with the chiefs and supers hired by some personnel departments—in firms where no operator's license is required—

Which of these round chart recorder inking problems do you now have?

- ☐ **Clogged pens because of open-bucket systems**
- ☐ **Frequent refilling . . . resulting in excessive maintenance**
- ☐ **The mess of syringes and droppers**
- ☐ **Breakage of plastic bags and glass ink containers**
- ☐ **Flooding or starving at pen tip**

New Esterbrook Mark-Trol solves them all, and completely pays for itself in days

Mark-Trol is a universal marking system . . . completely sealed . . . replaceable ink cartridge

Mark-Trol is a convenient conversion kit, enabling you to change over virtually any round chart recorder marking device in use today—in 10 minutes or less. Then your inking problems are over and done with.

Esterbrook knows that recorders don't operate in a vacuum, so they designed a marking device that does. From stylus tip to disposable ink cartridge, Mark-Trol is a completely sealed capillary system. You get a perfect chart record every time under any service condition, inside or out . . . humidity, precipitation, chemical fumes, dust, and in temperatures of from 0°F to 145°F. Contaminants are kept out, mess and mishaps are designed out. No clogging, flooding or starving. This faultless performance plus a generous ink supply in the cartridge mean that Mark-Trol operates up to 9 months without maintenance. And then the only servicing ever required is an occasional look through the window and replacement of the ink cartridge—and you do that in seconds.

Esterbrook has established a wholly new standard of reliability with Mark-Trol, and proved it in 2½ years of field tests in the power and processing fields.

ORDER ONE FOR TRIAL—We welcome your trying a make-sure installation with an order for a Mark-Trol kit.

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189 Van Rensselaer St., Buffalo 10, New York

Please send us . . . . . Mark-Trol Conversion Kits at $12.00 each.

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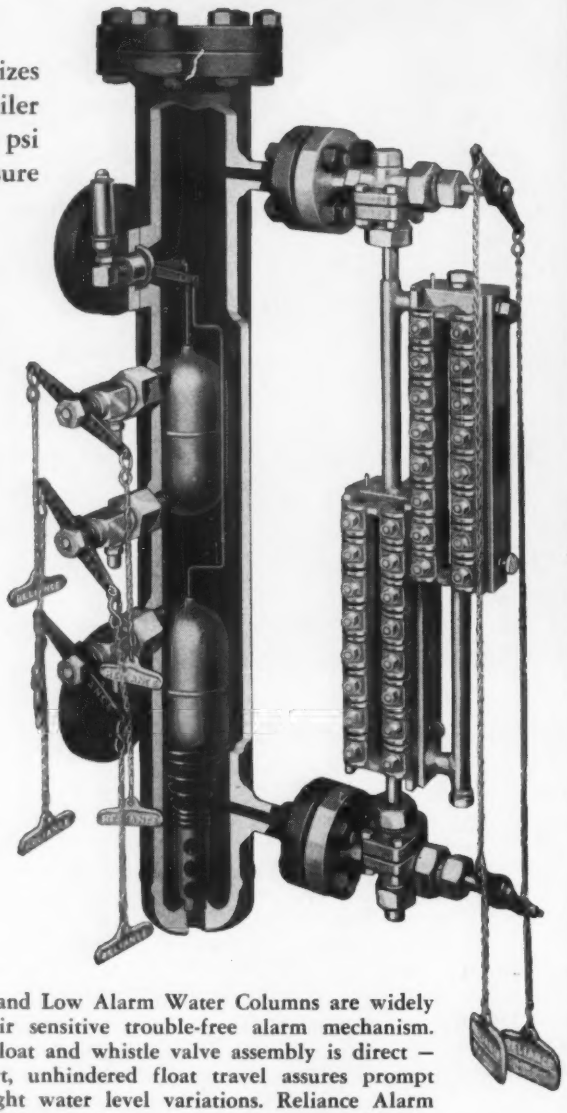
Please also send literature completely describing Mark-Trol. ☐

Insure safe, continuous boiler operation with **Reliance** Water Columns

Models and sizes for every boiler need to 2500 psi working pressure



Reliance High and Low Alarm Water Columns are widely known for their sensitive trouble-free alarm mechanism. Action of the float and whistle valve assembly is direct — foolproof. Short, unhindered float travel assures prompt response to slight water level variations. Reliance Alarm Columns, available to 900 psi, are completely assembled at factory and thoroughly tested before shipping . . . Above 900 psi, forged steel columns can be equipped to supply electric alarm service and other safety controls . . . Reliance also makes gage cocks, gage valves, gage inserts, illuminators and vision-focusing hoods in various styles to suit all needs. Engineer representatives in all principal cities.

The Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland 3, Ohio

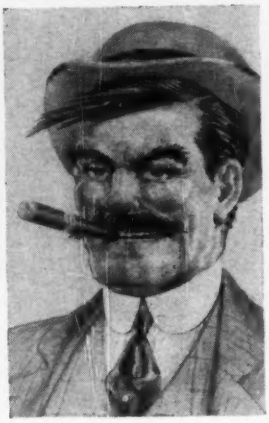
Reliance® BOILER SAFETY DEVICES

For more facts circle 307 on Reader Service card, p 117

Begins on page 154

you would agree that Marmaduke does not exaggerate. Marmy's philosophy, psychology and direct-mechanical-know-how approach would absolutely be lost on some supers, chiefs and foremen I have known. So long live Marmy! His experience and knowledge, gained the hard way in ship's engine and fire rooms and in shipyards, has saved many a power plant.

C G HOWARTER, *Canton, Ill.*



LOTS OF FRIENDS

We at Goodyear Tire & Rubber Co enjoy the Marmaduke stories immensely. Some of his friends here tell me his stories are available in book form. Please send the price—I want a copy for my library.

K F GILLUM, *New Bedford, Mass.*

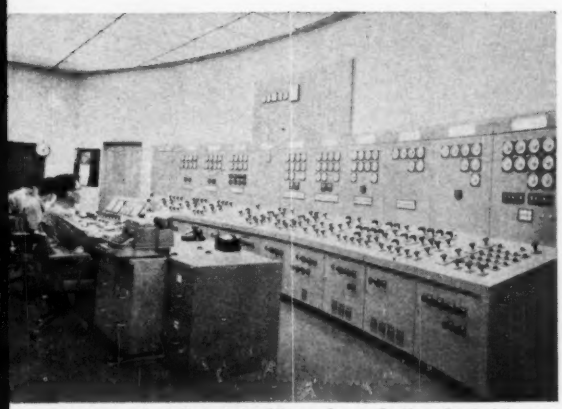
EDITOR'S NOTE: *Only 21 of the more than 150 stories are in the book,* The Marmaduke Story. POWER *sells it for $1.00.*

FATHER IMAGE?

Purchasing *The Marmaduke Story* and having it autographed by the author has made me a real hero and returned the "father image" to my household. My children now look upon me with respect because I have a book autographed by a real, live author. We all enjoyed the book thoroughly.

G HART, *Houston, Texas*

Another big Hydraulic Turbine and Generator by Hitachi



Switchboard installed at the Miboro Power Station, Central Japan.

Hitachi has recently completed two 137,500 kw/125,000 kVA hydraulic turbines and generators for the Miboro Power Station in Central Japan.

The turbine is of the vertical-shaft Francis type, and specified for a speed of 225 rpm, a maximum effective head of 200 m and 76.6 cu.m/sec water flow, making it one of the largest units of its kind in the world. Its runner has a maximum diameter of 3.7 m and the main shaft a diameter of 95 cm. The spiral casing, which was constructed in 13 sections to facilitate transportation to the site, has an inlet diameter of 3.35 m and an outer diameter of 11.2 m.

Since the generator was designed for a rated voltage of 16,500 volts and, in this respect, represents the first such attempt in Japan, particular care was taken in the corona-shielding and impulse resistance of the stator winding.

The generator is rated at 60 cycles, 225 rpm and 0.9 power factor but is also capable of operating at 50 cycles, 187.5 rpm and 1.0 power factor.

Hitachi, Ltd.
Tokyo Japan

Cable Address: "HITACHY" TOKYO

Now! Insulate and weatherproof tanks in one operation

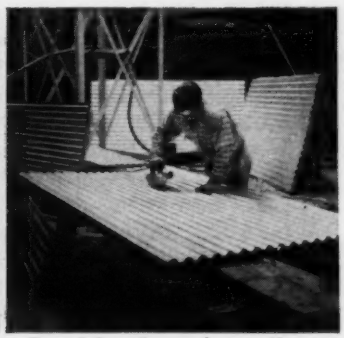
NEW J-M SPEED-INSUL GIVES YOU INSULATION AND ALUMINUM FACING IN A SINGLE PANEL

With Johns-Manville Speed-Insul®, you can insulate and weatherproof outdoor tanks in *one operation!* This prefabricated, corrosion-resistant panel consists of a highly efficient insulation material (J-M Spintex®) combined with a diamond-rib, sheet-aluminum facing.

Available in large 50" x 100" sheets, Speed-Insul is predrilled for the studs which are supplied with the system. What's more, these sheets can be cut and drilled in the field using a standard electric sabre saw and hand drill. The entire installation process is fast, economical and simple . . . so simple, in fact, your regular plant personnel can do the job.

For full details on this new J-M product, write to J. B. Jobe, Vice President, Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario. Cable: Johnmanvil.

Despite their large size, lightweight J-M Speed-Insul panels are easy to handle.



Speed-Insul can be easily cut with a standard sabre saw.

JOHNS-MANVILLE JM PRODUCTS

AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

For more facts circle 309 on Reader Service card, p 117

Powerscope . . . A selective look at

Magic survival sheet for Army?

Army Engineers' R&D Labs at Fort Belvoir, Va. have developed a handy gadget which survivors of sea disasters can use to make fresh water. It consists of a sheaf of five letter-sized sheets which are, from top to bottom: a black plastic film, a cloth, a water-repellent screen, a piece of aluminum foil and cloth backing the foil. When the conglomeration is soaked with sea water, then heated under the sun or by the survivor's body, fresh-water condensation forms on the foil. Survivor sops it up with a small sponge and drinks.

U.S.S.R. energy-production lead unlikely

Russian electric-energy production will probably run a little over 1000-billion kwhr in 1975 and around 1617-billion kwhr in 1980 says Philip Sporn, president of American Electric Power Co—despite the Soviet Communist Party's boast, made at their 22nd Congress, that over 3000-billion kwhr is the goal for 1980. "Most projections of electric-energy production in the U.S. for 1980 have been around 3000-billion kwhr. Since the draft of Soviet goals sets forth as an article of faith that the Russian economy will surpass that of the U.S. by 1980, it would hardly do," Sporn pointed out, "to show figures below the U.S. for that year." (See pp 91-3, this issue, for a more complete appraisal of the Russian power situation.)

Spain to make electric equipment

A program for the manufacture of electric apparatus will add 262,500 kw to the power capacity of Southern Spain by 1966. Westinghouse Electric International Co and two Spanish associates will work under instructions of the Instituto Nacional de Industria, Madrid. Total cost: about $11 million. Program includes seven 37,500-kw turbine-generators, one of which will go on the island of Mallorca, 170 miles off the mainland. Westinghouse-built equipment will serve as a prototype.

Prosperity is CEGB's loss

Britain's CEGB loses money despite prosperity. Sale of electricity in Great Britain in 1960 soared to an unprecedented height, according to Sir Christopher Hinton, chairman of the Central Electricity Generating Board. Increase over 1959 sales was 12.1%, largest rate of increase ever. But so unexpected was this jump in electric consumption that the CEGB lost $5-million: much of that power had to be generated in old, low-efficiency plants. Another contributing factor was significant outage of a new turbine-generator, causing a loss of $120,000 per day.

Power stations using coal as fuel are multiplying in Great Britain. The 480,000-kw Drakelow B Station was opened recently near Burton-on-Trent, and the Ministry of Power has authorized a 2-million-kw coal-fired station at Eggborough, Yorkshire—a twin to the recently authorized Ferrybridge plant. Full completion of these plants is slated to come between 1966 and '68.

L.A. boilers set

The new Haynes steam plant of the Los Angeles Board of Water & Power will have four boilers. They're scheduled to start up between 1962 and '65. First two are now being installed by Combustion Engineering Corp; the other two have been ordered from Babcock & Wilcox Company.

Lamp duplicates sunlight

Xenon high-pressure lamp accurately duplicates natural daylight or sunlight, two researchers told the Illuminating Engineering Society recently. W E Thouret and H S Strauss of Duro-Test Corp, N.J. explained that the lamps produce a continuous spectrum with energy distribution similar to the sun's in visible and ultraviolet regions. Close duplication of natural light is achieved without need for color correction. Besides, short-arc xenon lamps are bright, need little maintenance.

Gas turbine cuts cost at Austin

Austin Utilities of Austin, Minn. has installed a 5500-kw Westinghouse gas turbine for future combined-cycle operation. Gas turbine will be used in conjunction with a 22,000-kw steam turbine and its exhaust will heat station feedwater. With gas-turbine exhaust heat thus fully utilized, it is estimated that the combined cycle will reduce fuel consumption about 15.2%, compared to a conventional steam plant.

Bulk of German electricity from utilities

Great increase in power consumption in West Germany is predicted for the next 15 years. In 1975,

this month's power-field happenings

R J BENDER, Associate Editor

290-billion kwhr will be consumed against 109 billion in 1959, according to the German Assn of Industrial Power Economy. Power generation, on the other hand, should be around 286-billion kwhr in 1975, which means that Germany will still import a small percentage of its power. The Assn also predicts that the bulk of industrial firms will buy power from public utilities; only very large users—especially the mining industry—will generate their own power in Germany in the immediate future. (*McGraw-Hill World News*)

Drought dries dams in Yugoslavia

Electrochemical and metallurgical plants in Yugoslavia got no hydro power this fall because persistent drought dried up the dams. Domestic supply was not affected, but industrial power had to be imported during that period from Hungary, Italy and Austria; some was generated in old thermal plants reactivated for the purpose. Yugoslavia produced 744-million kwhr total energy in 1960, two-thirds of it being hydroelectric. Prompted by this year's experience, a new exchange agreement for electric power has just been signed between Yugoslavia and Austria. (*McGraw-Hill World News*)

Should lights be left on?

To turn off or not to turn off a fluorescent installation during short periods when no light is needed . . . that is the question taken under advisement by Westinghouse Lamp Dept engineers. Their tests compared cost of letting the lights stay on with cost of turning them off and increasing maintenance because of off-and-on operation. Results seem to favor letting the lamps burn. Each installation, however, must be judged on its own merit—small changes in conditions may lead to entirely different results.

Corona is studied at high altitudes

The Russians put great emphasis on the study of corona effects on high-tension lines, especially at high altitude, because of substantial energy losses encountered. The phenomena are studied both in ac and dc systems and up to 1.5-million v. Research is being conducted at altitudes of 10,000 to 12,000 ft above sea level in Armenia and Uzbekistan. Earlier corona studies were made at altitudes of 3000 to 6000 ft, and results were used in design and construction of power lines running through the mountains. (*McGraw-Hill World News*)

Top conductor temperatures defined

Assn of Insulated Power Cable Engineers has just released new definitions to cover three maximum temperatures of electric conductors. These definitions should clear up the confusion existing with regard to ambient temperature, hot-spot temperature and other terms presently used to describe conditions. These are the definitions: (1) *Maximum conductor temperature—operating:* highest conductor temperature attained by any part of the cable line under operating-current load. (2) *Maximum conductor temperature — emergency overload:* highest conductor temperature attained by any part of the cable line during emergency overload of specified time, magnitude and frequency of application. (3) *Maximum conductor temperature — short circuit:* highest conductor temperature attained by any part of the cable line during a short circuit of specified time and magnitude.

Pacific Northwest tests h-v lines

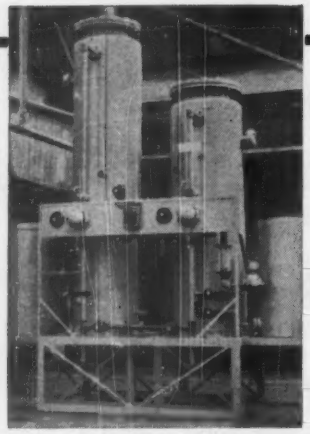
The first experimental 460- to 500-kv conductor west of the Rockies is being installed in the Pacific Northwest federal grid, according to Bonneville Power administrator C F Luce. Two 4000-ft sections of giant aluminum conductor, over 2-in. diameter, are being installed in BPA's 80-mile Big Eddy-McLoughlin 345-kv transmission lines near Sandy, Ore. Loadings of some 500 mw are economical at distances of 300 miles and over; for shorter distances, 1000-mw loadings per circuit are feasible. These five companies supply the test conductor: Aluminum Co of America, Kaiser Aluminum & Chemical Sales, Anaconda Wire & Cable Co, Olin Mathieson Chemical Corp and Reynolds Metals Co. Each company provides its own type of conductor. For example, Olin Mathieson supplies a 2.136-in. cable consisting of 90 aluminum wires laid spirally around a central hollow core.

Most expensive kwhr?

Do you realize that it costs you about $55,000 a kwhr to run your electric wrist watch? An Accutron watch runs on about 4 microwatts; its battery, which lasts one year, sets you back $1.50. On that basis:

$4 \times 24 \text{ hr} \times 365 \text{ days} = 2.7 \times 10^{4}$ **microwatt hr per yr or** 2.7×10^{-5} **kwhr per yr**

$$\frac{1.5}{2.7 \times 10^{-5}} = \$5.5 \times 10^{4}$$ **per kwhr!**



NEW FROM H&T
Low-Cost • High-Performance
"PACKAGE" DEMINERALIZERS!
TWO-BED and UN-A-BED
STANDARD UNITS

NOW AVAILABLE!!

Unless *special* conditions require you to use a *special* demineralizing system, you can save big money—and get excellent results—with the new H&T Standard "PACKAGE" DEMINERALIZER! Into these superior Standard Units, we've put the experience of 16 years in building many hundreds of manual and automatic demineralizing systems. *Result:* H&T "PACKAGE" DEMINERALIZERS are masterpieces of design and construction—unequalled in performance and wonderfully low in cost.

Write for details of Two-Bed and Un-A-Bed Demineralizers

H&T SERVICE

HUNGERFORD & TERRY, INC.
CLAYTON 3, NEW JERSEY

For more facts circle 310 on Reader Service card, p 117

HIGH PSI – HIGH TEMP.
NO PROBLEM...
with these Butterfly Valves!

★ Inlet pressures up to 6000 psi
★ Pressure drops to 1200 psi
★ Temp. range –300°F to +2000°F
★ Sizes 1" to 108" in all ASA ratings
★ Closing speeds fast as 1/3 second
★ Equal percentage flow characteristics for accurate flow control

FISHER-CONTINENTAL
Heavy Pattern
BUTTERFLY VALVES

WRITE FOR BULLETIN NO. 76

FISHER GOVERNOR COMPANY
Marshalltown, Iowa / Woodstock, Ontario / Rochester, England
Direct Inquiries to: CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Penna.

CONTINENTAL FISHER Control

For more facts circle 311 on Reader Service card, p 117

Calendar

Dec 6-8—American Institute of Mining, Metallurgical and Petroleum Engineers, Inc, 19th Electric Furnace Conference, Penn-Sheraton Hotel, Pittsburgh, Pa. Details: AIME, 345 E 47th St, New York 17, N. Y.

Dec 7-9—Canada's Power Show, Queen Elizabeth Bldg, Exhibition Park, Toronto. Details: W J Longeway, 410 Bloor St E, Toronto, Can.

1962

Jan 22-25—National Plant Engineering & Maintenance Show and Conference, Convention Hall, Philadelphia, Pa. Details: Clapp & Poliak, Inc, 341 Madison Ave, New York 17, N. Y.

Jan 24-26—American Society of Mechanical Engineers, Thermophysical Properties Symposium, Princeton U, Princeton, N. J. Details: ASME, Heat Transfer Div, 345 E 47th St, New York 17, N. Y.

Jan 29-Feb 1—Semiannual Meeting, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc, Chase-Park Plaza Hotel, St. Louis, Mo. Details: ASHRAE, 345 E 47th St, New York 17, N. Y.

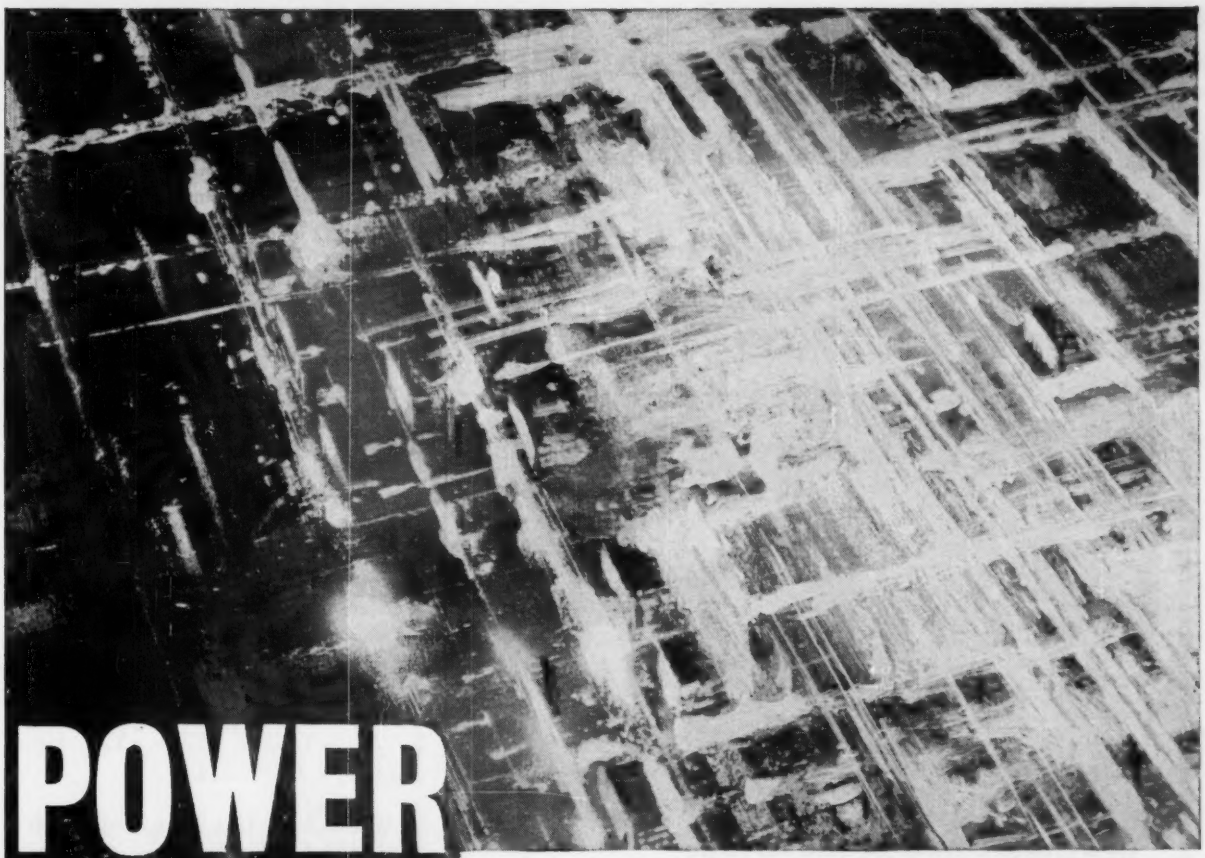
Jan 29-Feb 2—Electrical Engineering Exposition, held in conjunction with AIEE's Winter General Meeting, New York Coliseum. Details: Reber-Friel Co, 117 S 17th St, Philadelphia 3, Pa.

Feb 4-7—American Institute of Chemical Engineers, Meeting, Statler Hotel, Los Angeles, Calif. Details: AIChE, 345 E 47th St, New York 17, N. Y.

Feb 5-8—Fifth Biennial National Industrial Electric Heating Conference, cosponsored by NEMA and EEI, Netherland Hilton Hotel, Cincinnati, Ohio. Details: Industrial Electrification Council, 750 Third Ave, New York 17, N. Y.

Feb 11-17—National Electrical Week sponsored by electrical-industry groups. Details: NEW Committee, Suite 306, 407 N 8th St, St. Louis, Mo.

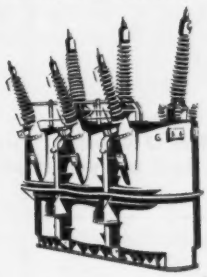
continued



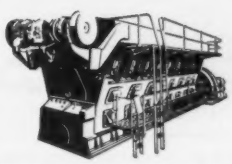
POWER ON CALL

THE WORLD DRAWS GREEDILY on electric power and light. Every day expanding industry, new public undertakings, improved transportation and increasing domestic load call for more and more power. Hawker Siddeley is helping to meet this demand by supplying the vital generation and distribution equipment. Their new subsidiary, Hawker Siddeley Engineering, will engineer and develop comprehensive power schemes—with or without automatic and/or remote control—anywhere in the world.

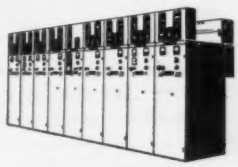
Fuller Electric builds all types of power and distribution transformers. This is one of a pair built for the new cross-Channel D.C. power link with France and believed to be the largest rectifier transformers in the world. Rating is 95/95/65 MVA 284/83.6/33 kV.



Mirrlees Monarch diesel engines are available as either 6, 8 or 10 cylinder vertical in-line units developing 1600 to 4,340 b.h.p. at 200 to 300 r.p.m. and also in 16 cylinder Vee form developing 7,000 b.h.p. at 375 r.p.m.



TheBrushSwitchgear range covers indoor and outdoor equipment for use on electricity supply and general industrial distribution systems of up to 33000 volts, 1000 MVA. This 440 voltswitchboard is for a television station.

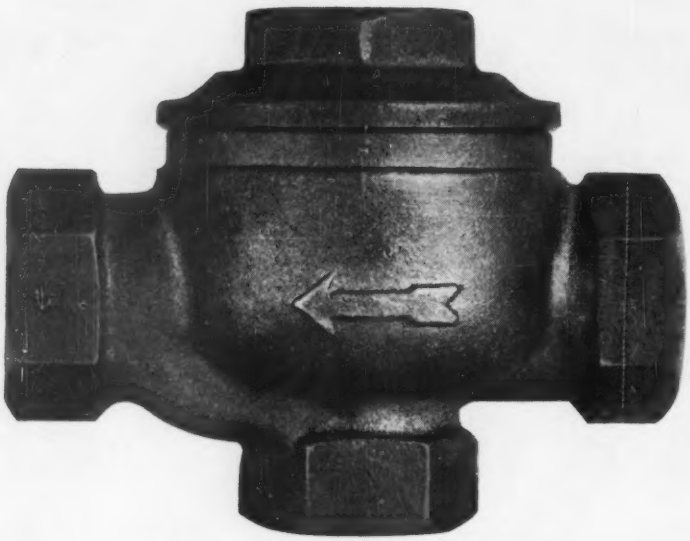


HAWKER SIDDELEY INDUSTRIES

Duke's Court, Duke Street, St. James's, London, S.W.1

For more facts circle 312 on Reader Service card, p 117

YOU CAN USE THIS!



BECAUSE PRICE IS IMPORTANT.
DON'T PAY FOR MORE THAN YOU NEED,
BUT DON'T PAY MORE AND GET LESS.
THE B&J TYPE GW STEAM TRAP GIVES YOU CONSTRUCTION AND PERFORMANCE FAR IN EXCESS OF ANY TRAP PRICED SO LOW.

- Discharges more condensate faster.
- Discharges more air faster.
- Operates with absolute uniformity.
- Priced with the lowest yet all working parts are monel and stainless steel.
- Only trap with factory assembled, calibrated and pre-tested replacement interior.
- There is a B&J thermostatic steam trap for almost every trapping job: pressures from vacuum to 300 PSIG, capacities to 25,000 lbs. per hour. Pipe sizes ½" to 2". Bronze, semi-steel, cast steel.

Don't take our word for it. Try a B & J steam trap for 30 days at our expense. Just tell us your capacity and pressure needs.

BARNES & JONES, INC.
34 Crafts St. • Newtonville 60, Massachusetts

For more facts circle 313 on Reader Service card, p 117

Calendar

Begins on page 172

Feb 12-15—12th Exposition of the Air-Conditioning, Heating and Refrigeration Industry, sponsored by ARI, Los Angeles Great Western Exhibit Center. Details: ARI, 1346 Conn. Ave, NW, Washington 6, D.C.

Feb 18-22—American Institute of Mining, Metallurgical and Petroleum Engineers, Annual Meeting, New York, N. Y. Details: AIME, 345 E 47th St, New York 17, N.Y.

Feb 19-22 — Fourth National Electrical Insulation Conference, sponsored by National Electrical Manufacturers Assn, American Institute of Electrical Engineers, Shoreham Hotel, Washington, D. C. Details: R Gingles, NEMA, 155 E 44th St, New York 17, N. Y.

March 4-8—Gas Turbine-Process Industries Conference, American Society of Mechanical Engineers, Shamrock Hilton Hotel, Houston, Tex. Details: ASME, 345 E 47th St, New York 17, N. Y.

March 14-16—Instrument Society of America, 12th Annual Conference on Instrumentation for the Iron & Steel Industry, Hotel Roosevelt, Pittsburgh. Details: H. M. Gravatt, Allegheny Ludlum Steel Corp, Research Lab, Brackenridge, Pa.

March 19-21 — Second National Electric Comfort Heating Exposition and Symposium, sponsored by Electric Comfort Heating Equipment Section of NEMA, Hotel Sherman, Chicago, Ill. Details: R Gingles, NEMA, 155 E 44th St, New York 17, N. Y.

March 19-23—National Association of Corrosion Engineers, 18th Annual Conference and Corrosion Show, Municipal Auditorium, Kansas City, Mo. Details: T J Hull, NACE, 1061 M&M Bldg, Houston 2, Tex.

March 20-29—American Chemical Society, 141st National Meeting, Washington, D. C. Details: ACS, 733 Third Ave, New York, N. Y.

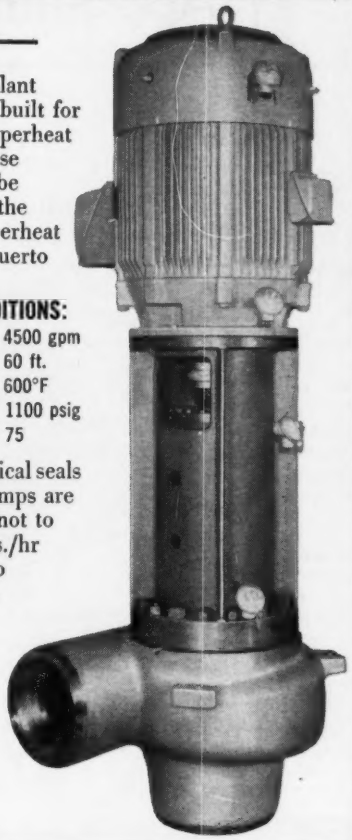
First—

Primary coolant pumps ever built for a nuclear superheat reactor. These pumps will be installed in the BONUS superheat reactor in Puerto Rico.

DESIGN CONDITIONS:

CAPACITY	4500 gpm
HEAD	60 ft.
TEMPERATURE	600°F
PRESSURE	1100 psig
HORSEPOWER	75

The mechanical seals on these pumps are guaranteed not to exceed 2 lbs./hr of leakage to atmosphere.

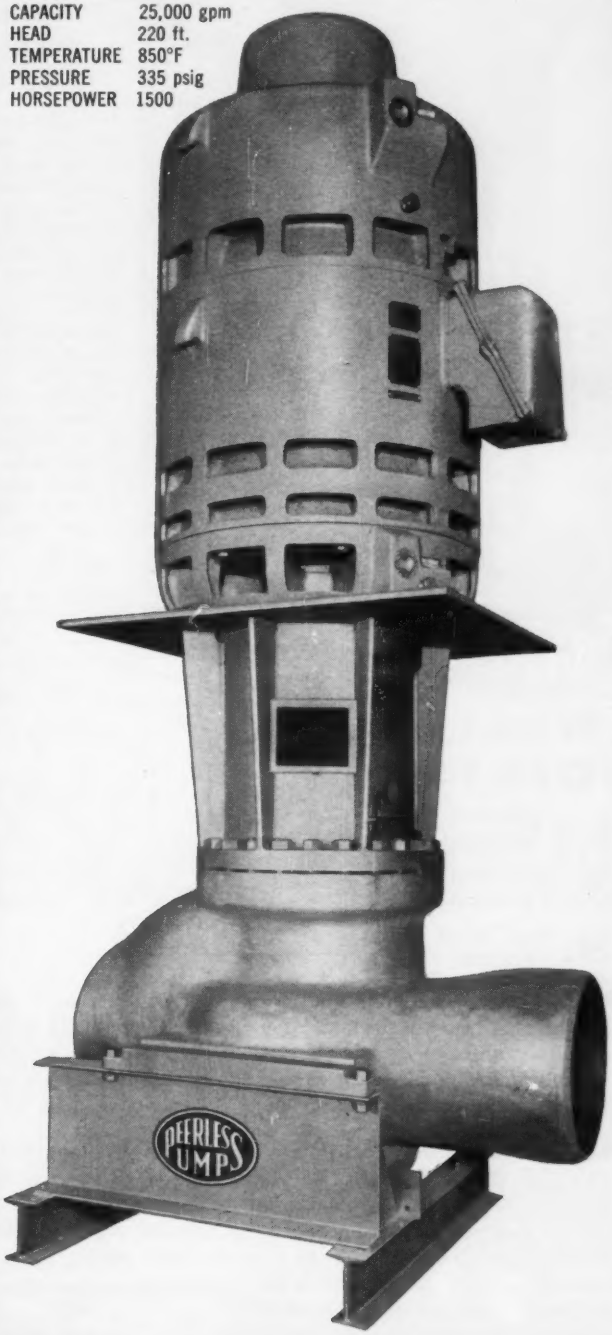


Largest—

Limited leakage primary coolant pump ever built. This 14 foot high mammoth will be installed at the NATIONAL REACTOR TEST STATION near Idaho Falls. This pump will handle an organic moderator. It has bearings specially designed to run in the pumped fluid.

DESIGN CONDITIONS:

CAPACITY	25,000 gpm
HEAD	220 ft.
TEMPERATURE	850°F
PRESSURE	335 psig
HORSEPOWER	1500



WHEN 36 YEARS OF PEERLESS PUMP EXPERIENCE IS PUT TO WORK— YOU GET RESULTS!

Results are what counts. And proven pumps are what you get when you deal with Peerless. Peerless offers you a complete follow-through program on any nuclear pump project. Development, manufacturing, quality control testing, hydraulic and mechanical testing, installation supervision and acceptance testing are among the many services offered. Either components or complete units can be provided.

For your next nuclear pump project, call on Peerless. For descriptive literature, request Bulletin PR-2. Write Peerless Pump, Hydrodynamics Division, FMC Corporation, 240 West Avenue 25, Los Angeles 31, California.

Another First—way back when the first forced circulation dual cycle reactor was built at Vallecitos, Peerless built and supplied this BWR circulation pump designed for 9000 gpm, 60 feet differential head at 544°F. System pressure is 1000 psi. It is just one of many limited leakage pumps built by Peerless.

fmc CORPORATION ®

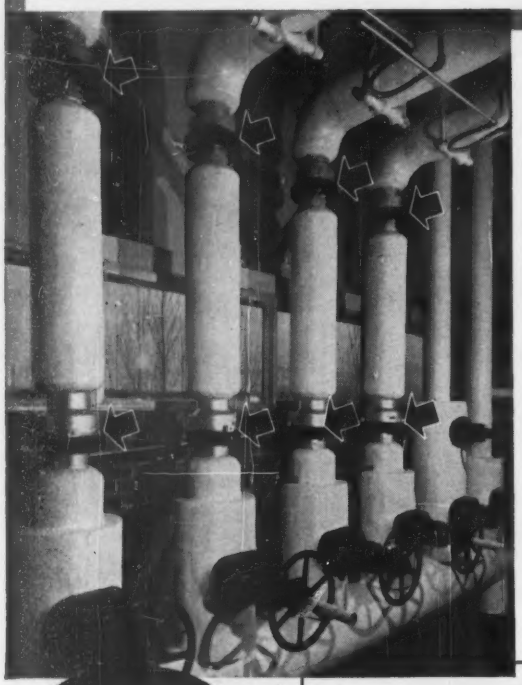
HYDRODYNAMICS DIVISION

PEERLESS PUMP

Plants: Los Angeles, Calif. • Indianapolis, Ind.

For more facts circle 314 on Reader Service card, p 117

Barco Solves Valve Piping Expansion Problem



Relieves Strain on Valves

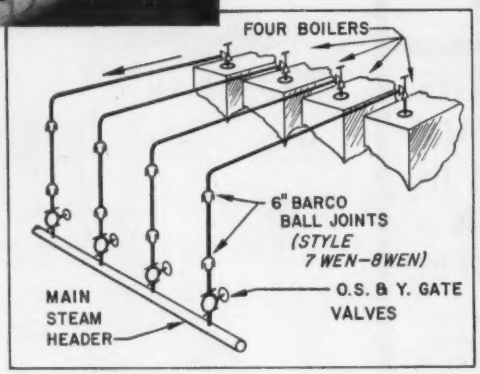
This photograph shows an interesting new installation of eight Barco Flexible Ball Joints (see arrows) on four 250 psi boiler steam lines in a West Coast industrial plant. The schematic diagram (below) shows the piping layout.

Due to the fact that operation of individual boilers is intermittent, complicated expansion, contraction, and torsional movements occur in the piping. All of these movements are easily accommodated with the aid of the Barco Joints, relieving reactive forces on the valves.

BARCO

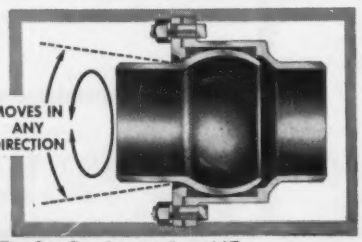
BALL JOINTS

1. Handle Expansion
2. Relieve Torsion
3. No "End Thrust"



PROBLEM—Originally, in the plant shown above, it was thought that the "spring" in the long runs of piping would take care of *thermal expansion* and *torsional stresses*. SUCH WAS NOT THE CASE. Serious trouble was encountered, tending to crack valve flanges and twisting so they would not seat tight.

ANSWER—Barco Ball Joints solved the problem, LOGICALLY, SIMPLY, ECONOMICALLY. These rugged all-steel joints have no thin wall sections, no critical points of fatigue, no rubber seals. They are practically indestructible. They provide points of flexibility in piping. Easy to engineer. They fit right in the piping; develop no "end thrust"; require no expensive anchoring. Sizes and styles to meet your requirements. *Send for catalog and information.*



BARCO MANUFACTURING CO.
522N Hough Street, Barrington, Illinois
In Canada: The Holden Co., Ltd., Montreal

For more facts circle 315 on Reader Service card, p 117

Appointments

Association elections

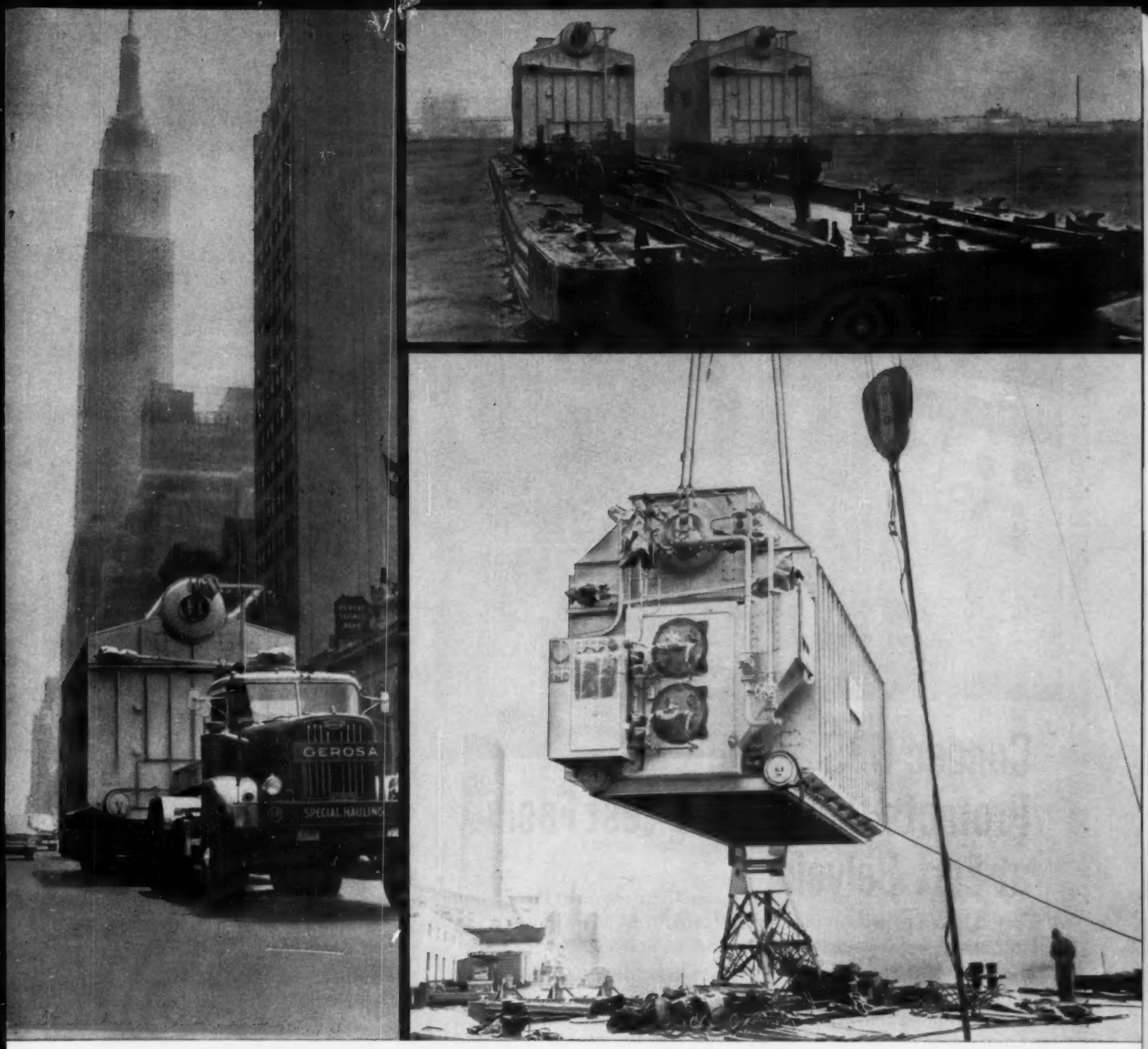
National Insulation Manufacturers Assn: F W Muller, vice-president of Gustin-Bacon Manufacturing Co, new president. **Insulated Power Cable Engineers Assn:** E G Driscoll, asst chief engineer of Phelps Dodge Copper Products Corp's Habirshaw Cable and Wire Div, president. **Welding Research Council-Engineering Foundation:** Babcock & Wilcox Co's Boiler Div vice-president, L S Wilcoxson, is chairman. **American Standards Assn:** R E Gay, former Bristol Brass Corp president, joins the Assn as managing director. **Ultrasonic Manufacturers Assn:** R S Mandelkorn, vice-president and general manager of Harris ASW Div of General Instrument Corp, president. **Vertical Turbine Pump Assn:** L W Firstenberger, president of Fiese & Firstenberger Manufacturing, Inc, president.

Presidents

Airco Co International: A M Andrews Jr. **Allen-Sherman-Hoff Fluid Transport Div,** new div of A-S-H Industries, Inc: L E Mylting. **Fitchburg Gas and Electric Light Co:** F E Manley. **Sterling Electric Motors, Inc:** A E Grazen—is also general manager.

Vice-presidents

United Electric Controls Co: S T Herr—executive vice-president and general manager. **Martin Co:** Dr R D Bennett—vice-president and general manager of Nuclear Div. **Henry Pratt Co:** W J Woolley—vice-president and general manager of Plate Div; R P Saar—vice-president, manager of engineering. **Fairbanks, Morse & Co:** F C DiLuzio—engineering vice-president of Beloit Group. **Specialty Valve, Trap & Controls Div,** White Sewing Machine Corp: H H Maltbie—vice-president and general manager. **Aqua-Chem, Inc:** R W Goeldner—vice-president of engineering. **Automatic**



VIA RAIL, BARGE AND TRUCK:

two 100,000 lb/hr steam generators move into heart of New York City

En route to Pennsylvania Station South Housing Project in Manhattan, this pair of Union Type MH Packaged Steam Generators demonstrates how steam requirements (in excess of 100,000 lbs./hr.) can be fulfilled without involving field assembly.

Placed by the contractor, Raisler Corporation, the two units were shipped complete with refractories, casing, MH Firing Units, and connecting duct work. Equipped for burning No. 6 oil, each of the MH's has a capacity of 100,000 lbs./hr. at 450 psi and 600° F.

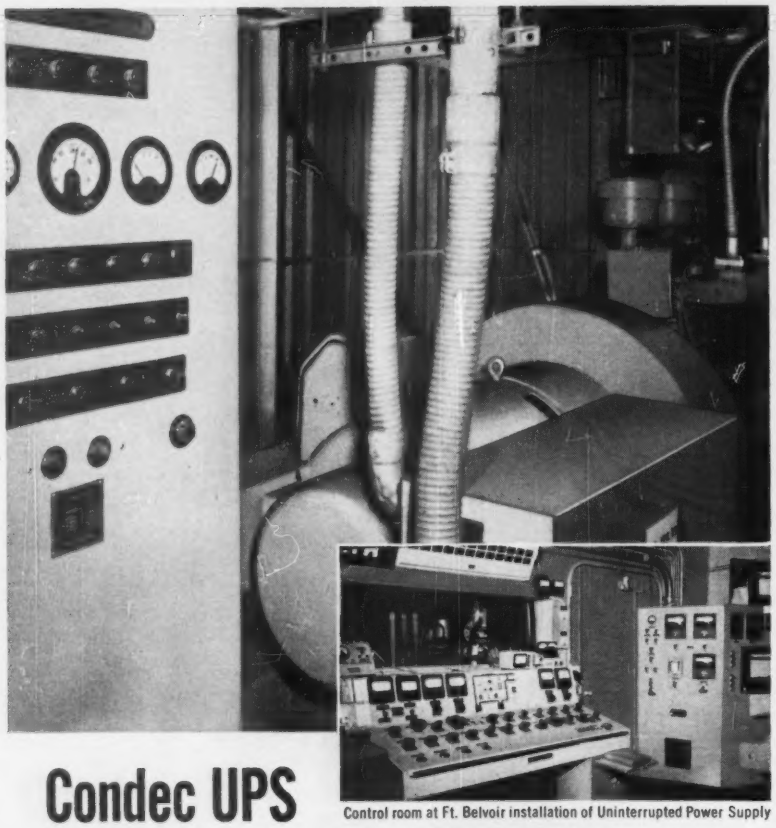
Shop assembled to standardized designs, Type MH Steam Generators and Firing Units can be supplied to handle diversified needs without costly special engineering. They can be arranged for oil or gas firing or both, with fully automatic, semi-automatic or manual control. The symmetrical, 3-drum MH design, with the top drum centered, makes it possible to ship larger units within existing rail clearances.

For detailed information, contact your local Riley Stoker Corporation or Union Iron Works office.

UNION

UNION IRON WORKS
ERIE, PENNSYLVANIA
A DIVISION OF RILEY STOKER CORP.

For more facts circle 316 on Reader Service card, p 117



Control room at Ft. Belvoir installation of Uninterrupted Power Supply

Condec UPS Protects Gas Turbine Test Facility at Fort Belvoir

A Condec Uninterrupted Power Supply has been chosen to protect the new gas turbine test facility at Ft. Belvoir against outages or serious voltage drops in commercial power.

Most critical item to be controlled is a gas-to-air heat exchanger, which is cooled by four electric-motor-driven fans. In power failure tests, it was determined that the heat exchanger materials reach a dangerous temperature in 1½ to 3 seconds, with complete loss of cooling air flow in 4 to 5 seconds.

Condec's UPS provides power without interruption for this important installation.

This is typical of UPS, which is unique in its capability to supply uninterrupted power — and maintain both voltage and frequency — for important military, industrial and commercial applications.

If power loss for even a few seconds can mean danger, damage or dollars to you, find out how Condec's UPS can eliminate this hazard. Write or call Mr. Frank Cesario, Power Equipment Division. Telephone DAvis 5-2261, DDD Code 203.

Uninterrupted Power Supplies specifications at Fort Belvoir

- 100 kw, 480 v, 3 phase, 60 cycle

frequency
- stability 1/6%
- regulation 1.5%
- frequency maintained above 58 cps

voltage
- stability ¼%
- regulation 2%
- surging — from no load to full load or vice versa, return to 2% in 0.5 second
- voltage maintained above 70%, below 110% rated capacity

POWER EQUIPMENT DIVISION

CONSOLIDATED DIESEL ELECTRIC CORPORATION

A Member of The Condec Group

STAMFORD, CONN.

For more facts circle 317 on Reader Service card, p 117

Appointments

Begins on page 176

Control Co: W G Brierley Jr—vice-president of engineering. **Union Carbide Nuclear Co:** C E Larson—company vice-president and general manager of Oak Ridge operations. **Research-Cottrell, Inc:** W C Osborne—vice-president of engineering and research.

General managers

American Measurement and Control Inc: Dr F D Ezekiel. **Compu-Dyne Electronics, Inc:** J H Bernstein. **Electro Rust-Proofing Corp:** H Neugold Jr.

General sales managers

Hungerford & Terry, Inc: A J Nauta. **Manning, Maxwell & Moore, Inc,** Gauge & Instruments Div: F J Murphy. **Packard Bell Computer Corp:** R F Musson. **Kline Manufacturing Co:** L J Stoutenburg. **De Laval Steam Turbine Co:** V E Bochnak—steam turbine sales.

Purchases

Crane Co has purchased assets of Deming Co. **Racine Hydraulics & Machinery, Inc** has acquired one-third interest in Gettys Manufacturing Co. **Tinker & Rasor** has acquired Detectron Co from Computer Measurements Corp. **Beckman Instruments, Inc** now has assets of Offner Electronics, Inc. **Nucleonic Controls Corp** has acquired Midwest Inspection Co. **Wheelabrator Corp** announces acquisition of W W Criswell Co, Inc.

New names

Transitel International Corp: has been formed to develop and produce solid-state digital transmission systems and components; C T Kastner is president. **Vapor Corp:** name change for Vapor Heating Corp. **Nihon-Racine:** new subsidiary in Tokyo of Racine Hydraulics & Machinery, Inc.

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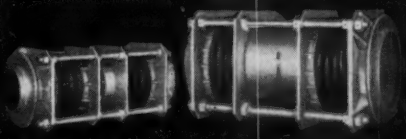
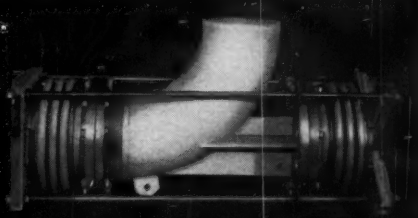
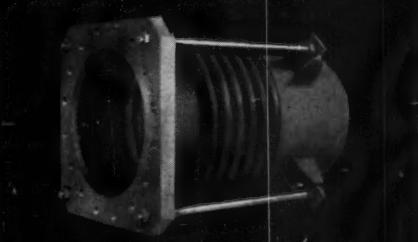


This pair of universal expansion joints is installed in the vapor piping of a gaseous diffusion plant. The lines carry Freon 114 at pressures up to 500 psig and temperatures ranging from −20°F to 300°F. Joints accommodate 3" lateral movement under these extremely harsh service conditions.



A 12" pressure balanced elbow assembly specially engineered by Badger for use in LOX storage and transfer facilities at an Air Force Missile Base. The unit is designed to operate at temperatures from −297°F to 250°F – a thermal shock range of nearly 550°! Operating pressures vary from 0 to 150 psig. Joint movement: 0.8" axial, 0.15" lateral.



One of eight specially engineered Badger Expansion Joints at a power plant for a gas recovery unit in Texas. Installation is on a cooling water piping of the surface condensers where service conditions require operation at 55 psig at a temperature of 107°F. The joints are designed to absorb ½" lateral movement in combination with ¼" axial movement.

This 24" x 44½" I.D. rectangular expansion joint, connects the turbine and condenser at a steam power plant. Each of the units is designed to operate at a pressure ranging from full vacuum to 1 psig at a temperature of 360°F. The joint handles ¼" axial compression and a plus or minus ⅛" lateral movement.

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For more facts circle 318 on Reader Service card, p 117

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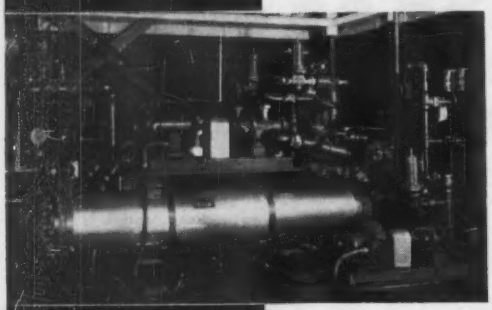
Enco systems employ one, two or more pumps and heaters, interconnected so that full capacity is possible with any combination of pumps and heaters. Flexibility of design permits the use of any combination of rotary pumps, with motor or turbine drive; or piston type steam pumps. Any part may be cut out of operation for inspection or cleaning, without shutting down, where two or more pumps and heaters are included in the unit system.



Heaters are insulated and jacketed with removable heads at both ends for cleaning without breaking any piping connections or removing any tube bundles.

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Write for Bulletin OB-53 describing Enco Gas and Oil Burners; and Pumping and Heating Equipment.

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By JOHN J. COOKE, Vice President & Secretary

Sworn to and subscribed before me this 18th day of September, 1961.

[SEAL] JANET A. HARTWICK
(My commission expires March 30, 1963)

Appointments

Begins on page 176

Retirements

Sydney T Maunder, General Electric Co advanced engineering consultant. He joins the University of Mass. as asst professor of electrical engineering.

Prof Howard H Aiken, director of Harvard University's Computation Lab. In 1939 he developed the basic plan for a large-scale digital computer.

Obituaries

H Gordon Nelson, senior vice-president of Edward Valves, Inc at the age of 64.

Lewis R Gaty, Philadelphia Electric Co vice-president of engineering and research and a nuclear scientist. He was 59.

Robert N Miers, 59, consultant to Allis-Chalmers Manufacturing Co's thermal power dept, on Oct 15.

Henry B Sirotek, immediate past president of the Assn of Diesel Specialists and one of its cofounders, on Oct 13.

Harold Torgersen, dean of University of Conn's School of Engrg, on Nov 5.

Engineers' bookshelf

Compressed Air and Gas Handbook, 3rd Edition, *7 x 10, illust, $8.00. Compressed Air and Gas Institute, 122 E 42nd St, New York 17, N.Y.*

This edition just came out, and therefore it's completely up to date. It is the combined work of over 20 authorities in the field and, except for basic data, is all new.

In addition to all compressor types, air and gas systems and end uses for compressed air and gas are covered. Latter category includes pneumatic tools, air-operated rock drills and associated equipment, conveyors, air cylinders and air-operated production machinery.

Please don't feed the "TUBE EATERS"

Don't let unnecessary pitting, cracking or erosion chew up tubes before their time. Don't let *any* type of corrosion, scale or biofouling hamper your heat exchange efficiency without checking these four factors:

● Is the tube alloy *right*? Will a vital difference in corrosion resistance result from a minor alloy change—or is an entirely different alloy called for? ● How much will performance be improved by Duplex bi-metallic tubes which provide the best metal or alloy for *each* heat transfer medium. ● Will a change to thickened-end or thickened-center tubes give needed extra resistance where attack is most severe? ● What actual data on similar exchanger operations are available?

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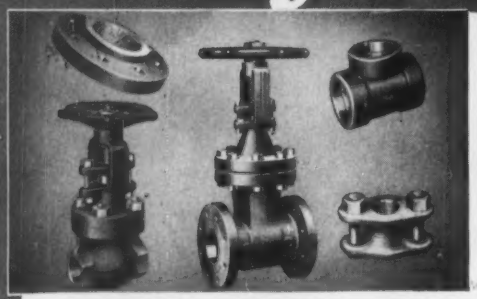
Designed for today's *Tough* service demands



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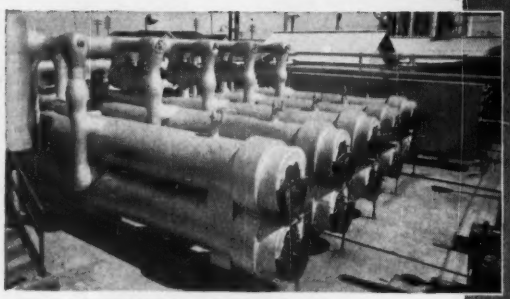

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Vogt constructs process equipment in wide variety to all Codes. Stills and towers, oil chillers, crystallizers, heat exchangers, molding machines, etc., serve in the manufacture of oils, greases, 100 octane gasoline, synthetic rubber, chemicals and related products around the world.

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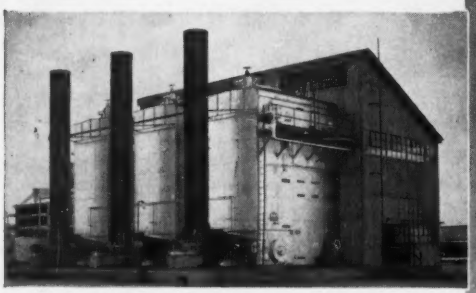
More than 70 years of engineering and manufacturing experience is incorporated in Vogt refrigerating and ice making equipment. Compression Systems and Tube-Ice Machines in a wide range of capacities serve industrial and processing plants and institutions here and abroad.



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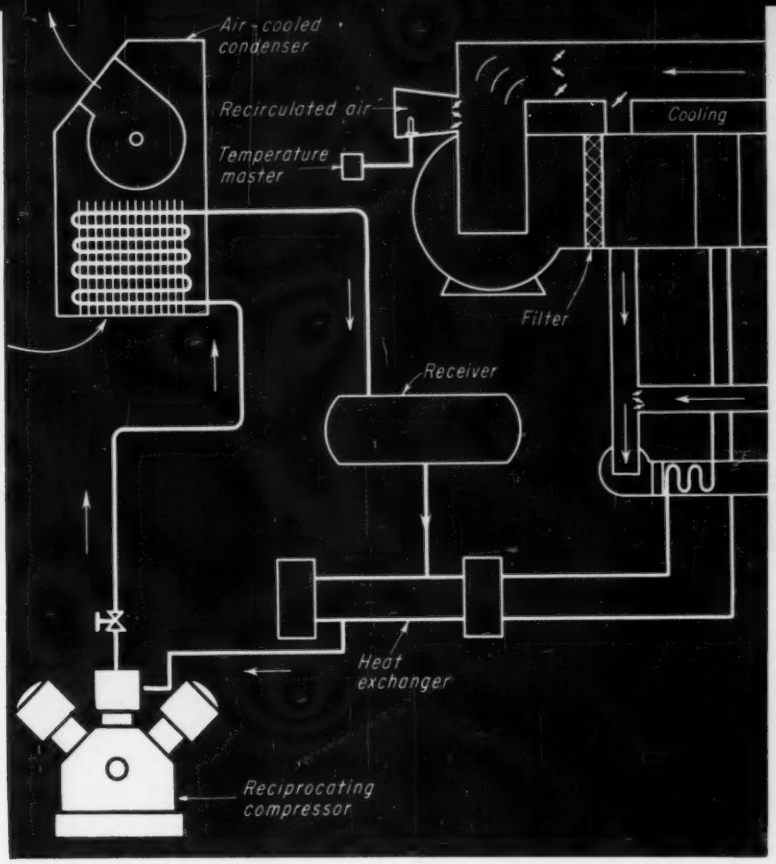


For efficient operation next summer, take advantage of the cold-weather shutdown to follow these . . .

9 steps in overhauling your reciprocating compressors

By WILLIAM J WREN, Carrier Air Conditioning Co

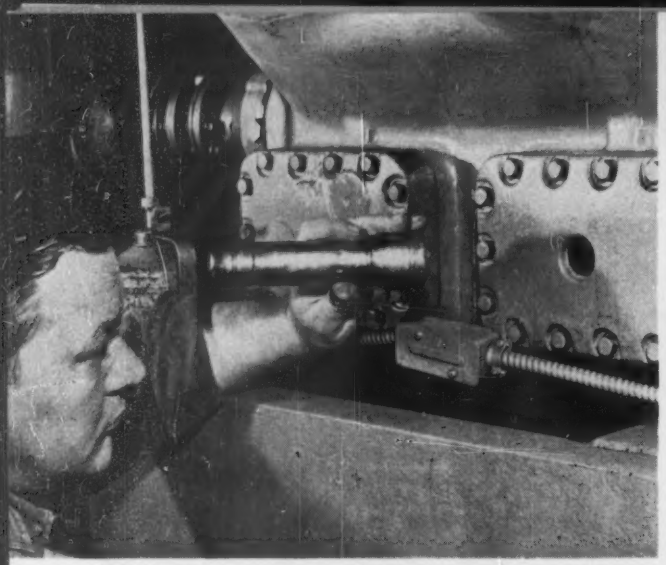
With the cooling season over for another year, your reciprocating compressors need attention, especially if they've been working at top capacity all summer.

Compact, piston-driven reciprocating compressors provide refrigeration in a wide range of capacities. They're usually installed in applied or built-up systems. The basic open compressor can be used with water-cooled, air-cooled or evaporative condensers—piston-drive principle also applies to a hermetic condensing unit and to a completely packaged chiller with a pre-engineered refrigeration cycle.

Today's reciprocating machines have been debugged. Various makers offer a host of design features promising reliable, trouble-free service—provided the compressors get their fair minimum of maintenance care. For example, Carrier machines have an automatic-unloading starter. In order to keep down starting torque so that a normal-torque motor can be used, an oil-pressure-actuated device unloads the compressor at startup. Automatic capacity control saves power and water by stepping machine capacity down as low as 25% of full load. Positive-pressure lubricator includes a pump which you can reverse by hand to assure proper oiling of bearings and wear surfaces as well as good oil circulation in shaft seal chambers.

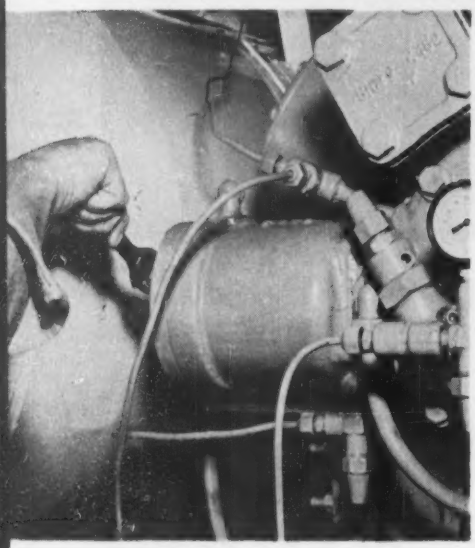
When machines are running, such components as these work to make your

EDITOR'S NOTE: *This is the third of a 5-part series on shutdown maintenance of air-conditioning and refrigeration systems, all authored by W J Wren. Other parts will cover cooling towers and air-handling systems.*

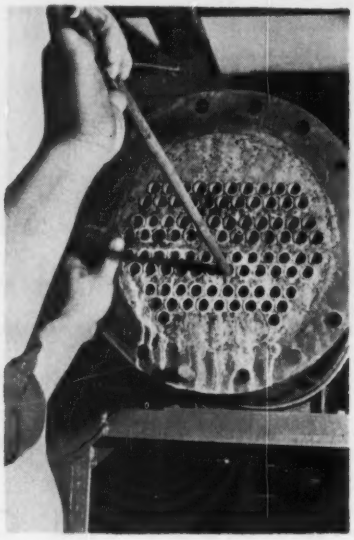


1 Oil level in compressor crankcase and general operating condition of the compressor are the first things for you to inspect

2 Check the refrigerant circuit for oil and refrigerant leaks. First make these inspections visually, then with halide torch



5 Condition of oil filter is vital—replace it after five months in service



6 Scale and mud are easily removed from condenser tubes with a special brush

7 Drain all water from system or add antifreeze if freezing weather is possible

continued

9 steps ready your unit for next year's cooling chores

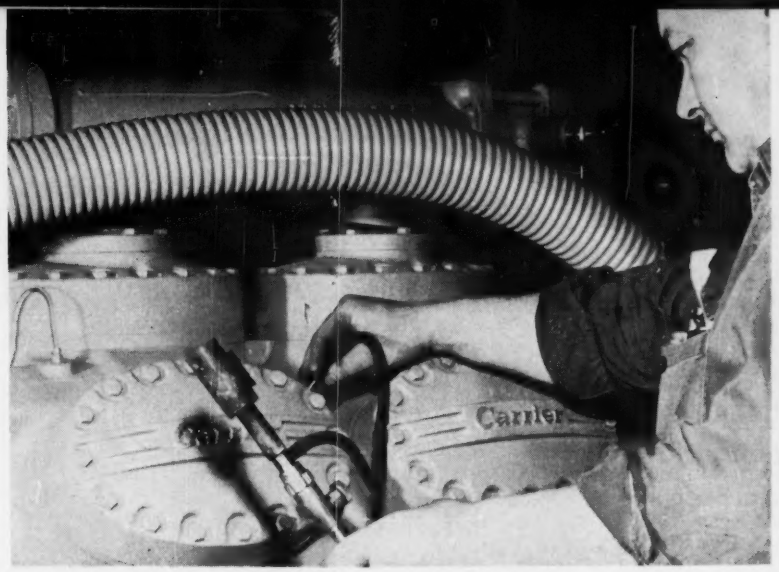
job a little simpler. But now, with the air-conditioning system idle, that minimum of preventive-maintenance care we spoke of must be done. Carefully check all parts of the compressor and carry out the overhaul operations shown above, so you'll be all ready to roll when hot weather sets in again. Here's a good procedure to follow:

Begin by taking an overall look at general operating condition. First inspect oil-pump operation and oil level, Fig. 1. Add oil if necessary. Check head and suction pressures, then make a pump-down capacity check according to manufacturer's instructions for your particular type of machine. Test the refrigerant charge and add refrigerant if it's needed. Check oil safety switch, starter and relays for smooth operation and proper calibration.

Inspect the refrigerant circuit for oil and refrigerant leaks—do this both visually and with a halide detector, Fig. 2 (we described this procedure in detail in the absorption-system article, Sept '61 and again in the overhaul procedure for centrifugal systems, Nov '61). Repair any leaks you find. Oil the motor bearings and check the drive belts or couplings for wear or misalignment. If yours is a machine with unloader, check it to be sure it's working right.

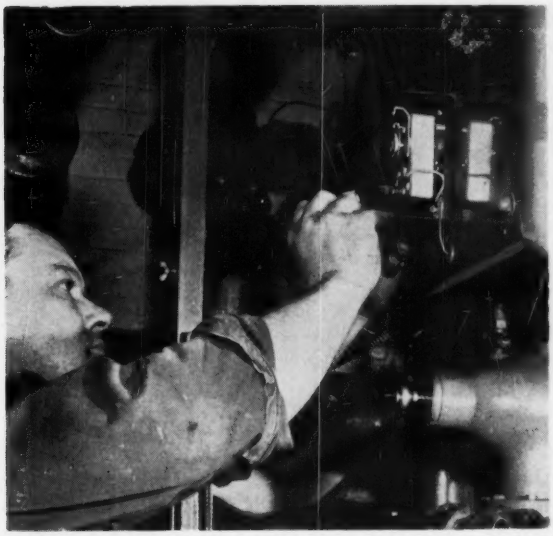
A running-time meter is a useful tool to clock total operating hours. On some makes of open compressor, bearing wear can be found without opening the machine. A special device can be inserted into the oil-pressure relief-valve hole; it's used together with a standard refrigeration gage. Resultant readings, checked against a chart in the instruction book, show the bearing's life expectancy.

Hermetic condensing package includes a compressor, condenser and controls. The hermetic compressor, with built-in drive motor, may also

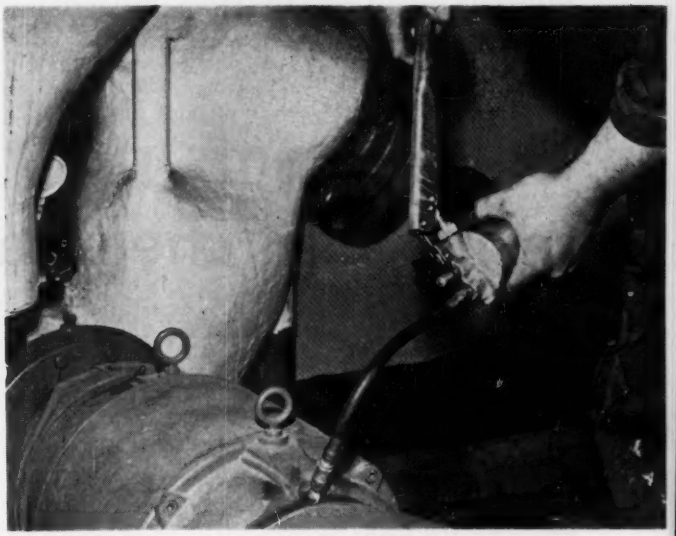


3 Thorough leak test is the most important maintenance check you can make on any system. This means going over all joints and connections, repairing any leaks you find

4 Electric connections have a way of working loose. Check them for tightness



8 Make sure the safety thermostat is operating properly by checking it as shown. Then you won't worry about accidents next year



9 Cooling-water pump often runs constantly during the warm months. Use manufacturer's recommended lube for its bearings

be installed separately for use with air cooler or evaporative condensers. As with the open machine, a thorough leak test is the most important part of your inspection routine. Check all joints and connections with a leak detector, Fig. 3.

Test all electric connections to be sure they're tight, Fig. 4. Make certain that oil-level gage and filter are in good condition, Fig. 5. If the filter has operated more than five months of the year it's smart basic policy to replace it whether it looks worn or not. See that the oil-pressure regulator is not clogged and that the plunger doesn't stick. Take a look at the pressure-relief valve and suction- and discharge-valve disks. See how many amperes the motor is drawing.

Test refrigerant charge by observing the liquid-line sight glass or by opening the liquid-level test cock. Flashing bubbles appearing in the glass or liquid flowing from the test cock indicates inadequate charge. Should you suspect an overcharge, reduce the charge, then recharge the system until you reach the proper level.

Inspect the water side of shell-and-tube condensers by removing their heads. Once again your halide detector comes into service as you look for leaks in the tubes and tube sheet. Soft scale or mud can be cleaned with a special brush, Fig. 6. Be sure to flush water through the tubes while brushing.

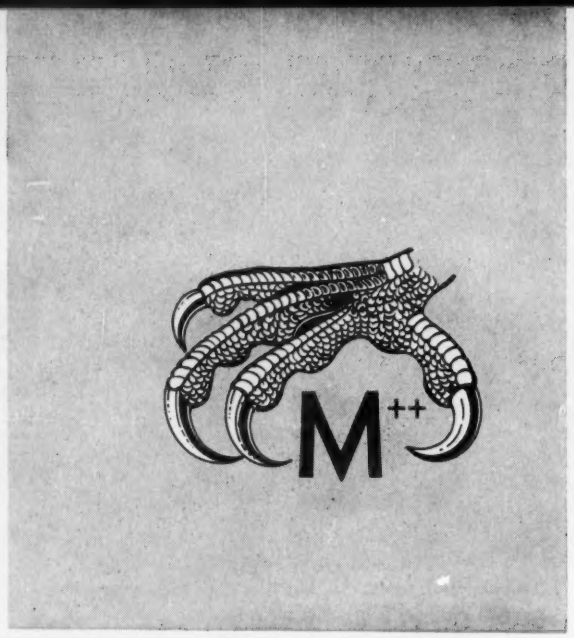
If ambient temperature may drop below freezing, protect the unit either by draining all water, Fig. 7, or by adding antifreeze.

Liquid chillers are completely packaged units. The many arrangements available may include a multicylinder compressor, condenser, cooler, refrigerant piping and controls.

Compressor and condenser maintenance takes the form we explained in connection with hermetic units. To prepare for winter, drain the condensing water. But don't drain chilled water unless temperatures are likely to drop to the subfreezing zone.

Check operation of the safety thermostat, Fig. 8, and oil-failure switch. Then just lubricate the water pump, Fig. 9, and you're all set to beat the heat next cooling season.

While sequestering agents can't compete economically with inhibited muriatic acid for chemical cleaning, their special properties can significantly improve many industrial maintenance techniques. In this article an expert discusses basic chemical concepts and explains how . . .



BIRD CLAW symbolizes chelation (pronounced *key-lation*)—actually the clutching of the metal ion by a complex multiligand formation

Sequestrants play vital role in modern chemical cleaning

By C M LOUCKS PhD, Consulting Chemist

For several years, commercial products have been available to sequester, chelate or form chemical complexes—with varying degrees of practical usefulness. These terms have slightly different meanings (box, facing page) but all involve the same phenomena: a simple metal ion or cation in water solution is attached or surrounded by a molecular or ionic superstructure that completely changes identity and properties of the simple ion to the point where its own pardner literally can no longer recognize it. The new ion or species formed is stable if the complex is held together by strong enough forces. In a stable complex there is little tendency to revert to original parts, so the simple metal cation essentially disappears.

One practical application is preventing solids from precipitating in water. If the simple cation causes soap curds, hardness scale, spots on fabrics or streaks on glassware, complex or sequestering action may be just what is needed. (Ca^{++} and Mg^{++} are culprits here; compounds of iron and manganese also spot fabrics.) Maybe we can get a complexing agent that will grab hold of the offending ions with one, two or more hands and hold on tight enough to change "bad" ions into "good" ones that won't cause trouble. This can be done, to prevent undesirable solid phases from forming. Of course, these troublesome ions can also be handled by conventional water-treating methods. Adding the right reagents precipitates them as an insoluble sludge which then can be separated and removed. Ion-exchange techniques substitute more friendly ions or perhaps remove all of the troublesome ones from solution.

Another practical use is causing solid phases to disappear. It seems reasonable that any technique which keeps an undesirable solid phase from forming at all may also redissolve a solid phase after it has formed—same basic concept is involved. Suppose crystals of $CaCO_3$ are placed in a beaker of water. We see nothing remarkable happen and may conclude that $CaCO_3$ doesn't dissolve in water. But this isn't quite true because low concentrations of Ca^{++} and CO_3^{--} are present. After they reach a certain value, these concentrations do not change. A state of equilibrium actually exists between solid $CaCO_3$ crystals and the Ca^{++} and CO_3^{--} ions in solution. This is shown by:

$$CaCO_3\ (solid\ phase) \rightleftharpoons Ca^{++} + CO_3^{--}\ (solution)$$

It is important to understand that two reactions, as shown by the double arrows, are going on all the time. Ions in solution phase at right are not the same ones that were there a half hour ago. They have joined the solid phase by attaching to crystal faces and new ones have left crystal faces to enter solution phase. But to the casual observer nothing is happening because the rates of the reactions are equal. An equilibrium exists.

Now, imagine we could reach into this solution with a pair of forceps and physically bring out either one of these ions. This disturbs the equilibrium—reaction from right to left is interrupted but not the one from left to right. If we keep removing either ion species fast enough to main-

Let's define the terms 'chelating' and 'sequestering'

Suppose we first clarify the chemists' use of the words *simple* and *complex*. A single ion such as Cl^- can certainly be considered simple. But what about oxygen anions such as SO_3^{--}, CO_3^{--}, NO_3^-, etc? Would you call them simple or complex? Opinions vary, but few chemists call them complex ions.

Now take a solution containing Fe^{+++} ions and add SCN^- ions. These tend to form a blood-red species that serves as a qualitative test for ferric ion. In theory, Fe^{+++} is the central figure with the SCN^- ions gathered around it. The number gathered does not depend on ordinary valence rules, but more on ion sizes, space geometry and how many unpaired electrons are available to *hold hands*. No one quarrels with calling this a complex ion or molecule.

Complex individuals are formed by uniting simpler ion or molecular species; sometimes we don't know the exact formula or just how the ions take hold of each other. Some complexes are so stable that finding a simple ion in solution is like looking for a needle in a haystack. Chemical cleaning is concerned only with water-soluble complexes.

Another familiar complex is the deep-blue-colored ion of $Cu(NH_3)_4^{++}$. When the CU++ and the NH_3's combine like this, we believe each NH_3 holds Cu^{++} with one hand. Simple ammonia derivatives like $C_2H_5.NH_2$ do the same thing. But suppose the Cu^{++} meets ethylene diamine with two nitrogen groups. Can this creature grab on with both ends? There is evidence it takes hold with two hands or ligands.

A *chelating agent* is one that forms complexes with metal ions by holding on with multiple ligands. *Chelate* comes from the Greek word for claw. The metal ion is held in the claw of the other species.

One of the best-known agents is derived from ethylene diamine tetra-acetic acid or EDTA. When one of these things gets Ca^{++} in its clutches, we aren't sure how many ligands there are, but we do know the chelate is very stable and useful.

Now we come to sequestering agents. The word is derived from the verb *to sequester*, meaning, the dictionary says, "to put aside, separate from society or public life, remove, seclude." If water contains Ca^{++}'s that cause trouble, nothing would please us more than to separate Ca^{++} from the society of the other ions. How can we do this? Just add an ion or other molecular species that gobbles up the Ca^{++} so completely that for practical purposes it doesn't exist in solution any more. So we have sequestered the Ca^{++} by forming a complex species. If complexing agent forms a multiple ligand hold on the metal, we generally call it a chelating agent.

tain their concentrations below equilibrium values the left reaction will never catch up with the right reaction and the solid phase will eventually disappear.

There are at least two methods of doing chemically what we have done in theory with our pair of forceps. We can add an acid to obtain H^+ ions. These have a liking for CO_3^{--} ions and merge with them to form carbonic acid, an unstable compound that decomposes into H_2O and CO_2 with the CO_2 gas bubbling up and out of the solution. Ion concentrations never reach equilibrium and the struggle is lost. The $CaCO_3$ crystals disappear, accompanied by a rapid evolution of CO_2 gas.

But if acid is undesirable for some reason, can we work on Ca^{++} with the complexing or sequestering trick and alter its identity so the left reaction is interrupted for want of Ca^{++}? Yes—same sequestrant that keeps soap curds, glass streaks and hardness scale from forming also makes the $CaCO_3$ effectively disappear.

Chemical cleaning is basically concerned with making solid phases disappear. In the case of $CaCO_3$, of course, it is much cheaper to use hydrochloric acid than any sequestrant now available. But if acid is objectionable for any reason you can fall back on this other method.

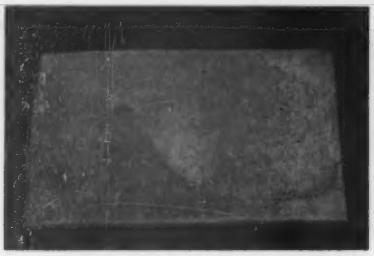
Calcium-sulfate scale is dissolved by sequestrants in the same way they work on $CaCO_3$. But in the case of $CaSO_4$ there is no cheap and easy alternative (you can perhaps reason out why acids won't work). So technically, a sequestrant is the ideal answer for removing this scale.

Certain boiler deposits are compounds of Ca^{++} and Mg^{++}. Sludge is deliberately formed by adding PO_4^{---} ions. Any water hardness that sneaks through the water-treating department precipitates as insoluble phosphates of calcium and magnesium. This reaction can be written:

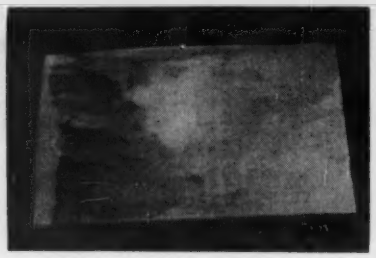
Metal phosphate (solid phase) $\rightleftharpoons$ $xM^{++} + yPO_4^{---}$

M stands for Ca^{++} or Mg^{++}. If either M^{++} or PO_4^{---} can be altered in identity and removed from this equilibrium situation, the sludge will dissolve. As with $CaCO_3$, this can be done in two different ways, but the acid works for a different reason. With carbonate the reaction product CO_2 flew out the top and escaped. In this case nothing escapes, but the PO_4^{---} and H^+ have such an ardent desire to unite that PO_4^{---} changes to a large extent into HPO_4^{--}. Thus identity of PO_4^{---} is altered, equilibrium shifts to right of equation and the sludge dissolves. The same job is handled by a chelating agent that ties up Ca^{++} and Mg^{++} in very stable complexes; choice of method again boils down to a matter of relative expense, ease of handling, etc. Since the chelating agent for this service handles easily and is safe to use even if the boiler has a fire in it, there are good talking points for both ways.

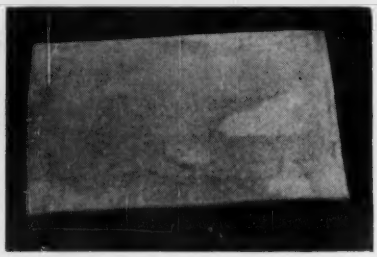
Iron oxides present another special problem. Can they be dissolved in something other than acids? This is a long and interesting story all by itself, and the job isn't a cinch. Speaking both physically and chemically, there are many iron oxides and some are harder than others to dissolve, even in acids. One class of chelating agent does some dis-



STEEL COUPON after exposure to acid treatment is free of all rust and mill scale



AFTER-RUST is a brown-black discoloration occurring right after washing with water



COMPLEXING AGENT in caustic solution dissolves after-rust, leaving clean coupon

Complexing agents can eliminate much of the rinsing

solving in the pH range around and above neutral. Rust and mill scale have been removed from a small new boiler by a chelating agent at an initial pH of 6 by boiling the solution for several hours. A similar solution, propelled by steam through 1100 ft of 3-in. steel line, has removed rust and mill scale.

Other types of chelating or sequestering agents dissolve the iron oxide, to some extent, in strong alkaline solutions. One is employed in the rather common strongly alkaline rust removers and is frequently found in alkaline washing solutions. There it combines with hardness ions to form soluble complexes and prevent the formation of any unsightly streaks on washed surfaces—so glassware can be rinsed to sparkling clarity. Another sequestering agent for iron in strongly alkaline solutions works on metal ions like iron and copper, but not on hardness.

Citric acid is taking on greater importance. Because of its property of forming complex ions with dissolved iron, this acid has been used to clean some modern high-pressure boilers. Equilibrium between iron oxide and iron in solution can be written as:

$$\textit{Iron oxide (solid phase)} \rightleftharpoons Fe^{+++} + XOH^{-}$$

We recognize this as pretty arbitrary symbolism, but it outlines the method of approach. Attacking the hydroxyl ion is a job for acids, and in general metal oxides do dissolve in acid. But citric acid and some others have a double-barreled approach, furnishing not only H^+ ions but citrate ions which tend to form fairly stable complexes with dissolved iron.

You can easily observe this effect. Place equal portions of iron oxide in two beakers, then pour citric-acid solution only in one beaker. In the other put the same quantity of citrate, but just half in the form of acid, the rest as a citrate salt to furnish a lot of citrate ions immediately. Keep the two beakers under identical conditions and take periodic samples for iron determinations. Iron concentration rises more rapidly in the second beaker than in the first, emphasizing importance of the citrate ions.

When iron oxide dissolves in hydrochloric acid, the partly spent acid solution, diluted with large volumes of water, soon becomes turbid. A solid phase forms that eventually coagulates as sludge. A check of pH finds it still on the acid side of neutral—it may be quite acid. This means there is not much likelihood of rinsing hydrochloric-acid solution from a boiler with water without sludge forming before rinsing is completed.

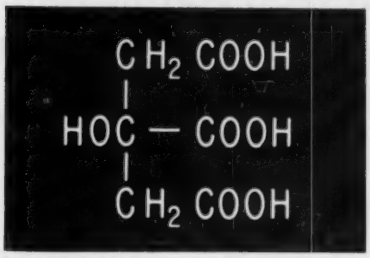
This is then not a problem with citric acid. Rinsing can go on until pH is at neutral or above. Even if the acid is displaced with water containing compounds such as ammonia and hydrazine, the iron-citrate complex is stable enough to keep red iron-oxide sludge from forming. Recently, even when hydrochloric acid is employed for cleaning, it has been common practice to add very small amounts of citric acid to rinse water to prevent iron compounds from precipitating.

For practical industrial use, complexing or sequestering agents must be available in substantial amounts at prices the user will pay. Chemical formulas for some common compounds are shown on facing page. We've just covered citric acid's ability to form iron complexes. The polyphosphates are widely used for sequestering water-hardness ions and preventing scale and soap curds. These compounds are employed in water treatment and in compounding detergents and cleaning compounds. Other sequestrants form more stable complexes than polyphosphates; they are more effective in redissolving solid phases.

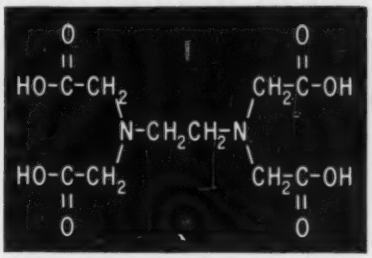
Ethylene diamine tetra-acetic acid (EDTA), right, is typical of a large class of complex-forming materials that contain both acid (–COOH) groups and the amine nucleus ($-N^{--}$). Since all form multiligand complexes they are generally called chelating agents. EDTA forms mol:mol complexes with hardness ions; many other heavy-metal ions. The Ca^{++} complex is very stable, the Mg^{++} somewhat less so, but usually stable enough to take Mg^{++} out of circulation. EDTA is not suitable for complexing iron at high pH because if enough OH^- is around, it competes with EDTA for possession of Fe^{+++} ions. At 8 to 10 pH, competition gets too much for EDTA and insoluble iron hydroxide or hydrated oxide forms.

Some amine-acid agents are more effective at higher pH than others, but when pH gets above 10, it's wise to consider another type. Fortunately there are sequestrants which seem particularly effective at high pH—even in solutions of caustic soda, in fact. Perhaps those most widely known and used in this category are derived from the so-called sugar acids. Table sugar (sucrose), a com-

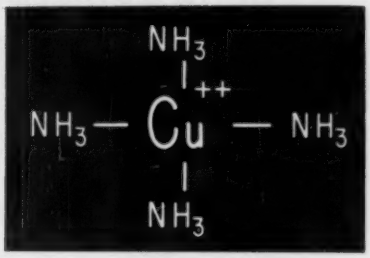
Variety of chemicals have sequestering and chelating properties



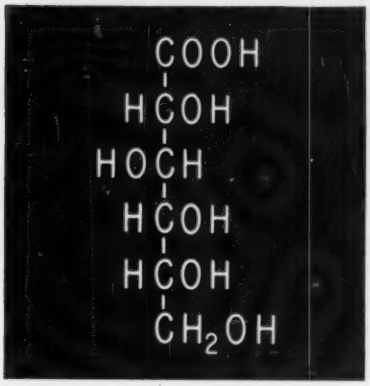
POLYCARBOXYLIC (CITRIC) ACID dissolves iron oxide, complexes iron to 10 pH



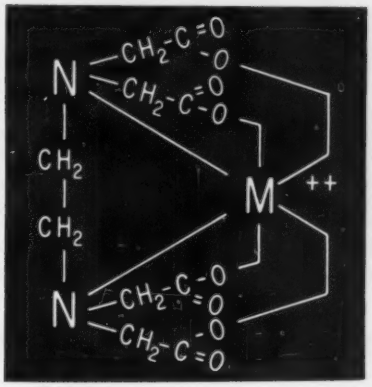
EDTA is typical amine-acid species, but the iron complexes are not stable at high pH



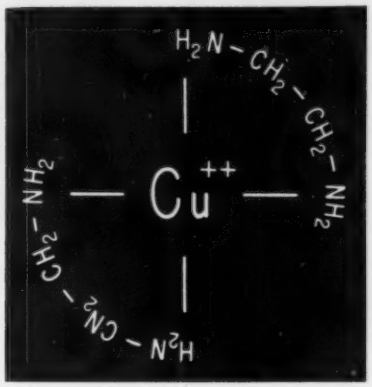
COPPER-AMMONIA COMPLEX is single-ligand type. Four NH_3's aren't in same plane



POLY-HYDROXY (GLUCONIC) ACID, derived from sugar, also dissolves iron oxide



EDTA-METAL in complex structure shows multiligand or clawlike grip on metal ion



ETHYLENE DIAMINE with NH_2 group on each end forms complex with copper ion

pound with the formula $C_{12}H_{22}O_{11}$, is split by a simple chemical reaction called hydrolysis into two 6-carbon molecules, one of which is glucose. A process of oxidation converts glucose into gluconic acid.

Some of these polyhydroxy acids are good sequestering agents. Sequestering is done by the large polyhydroxy anion, not the acid itself. So sodium gluconate is also a sequestrant. These types grab Ca^{++}, Mg^{++}, Fe^{+++} and other cations at high pH—they differ in this respect from the EDTA family.

Tri-ethanol amine is another sequestrant useful at high pH ranges. It doesn't handle Ca^{++} and Mg^{++}, but does sequester iron and copper and can be very useful, for example, after cleaning a public-utility boiler with acid solvents. These boilers are usually fouled with iron oxide and metallic copper, so only ions that must be rinsed out are iron and copper. Ca^{++} and Mg^{++} are normally absent since only distilled or demineralized water is used for makeup. Both gluconate and tri-ethanol amine are used in strong caustic solutions as rust strippers. At boiling temperatures they dissolve some red iron oxide and freshly precipitated black oxide, but are not very good solvents for mill scale. In boiler cleaning, if after-rust forms during draining and rinsing without an inert gas blanket, it can be removed by boiling with an alkaline-sequestrant solution. Photographs of metal coupons, facing page, show effectiveness of complexing agent in removing after-rust. In this area, however, additional exploratory work is needed.

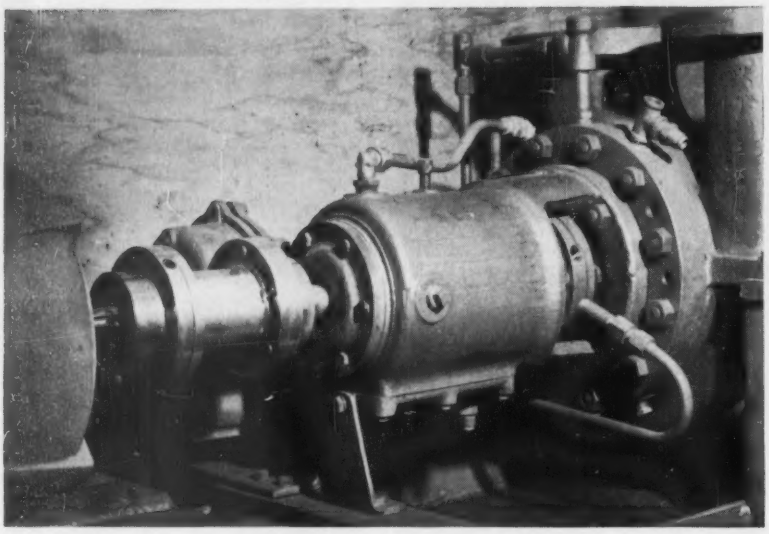
What's ahead for sequestering agents? If you followed our line of reasoning up to this point you have noted that industrial maintenance cleaning involves dissolving solid phases and rinsing acids from equipment to prevent solids formation. These two problems are essentially one. Sequestrants are now used to a limited extent in cleaning and rinsing, and their use will increase. They are capable of greatly improving chemical-cleaning methods.

For example, why not use sequestrants to eliminate much of the rinsing? When acid solution is drained from a boiler the relatively small amount of partly spent acid remaining contains ions like Ca^{++}, Mg^{++}, Fe^{+++}. Estimates of acid quantity range downward from 1% of boiler volume, and this acid must be removed without precipitating dissolved salts. So the boiler is carefully filled once, twice, or even three times and citric acid may be added to the rinse to keep iron compounds in solution.

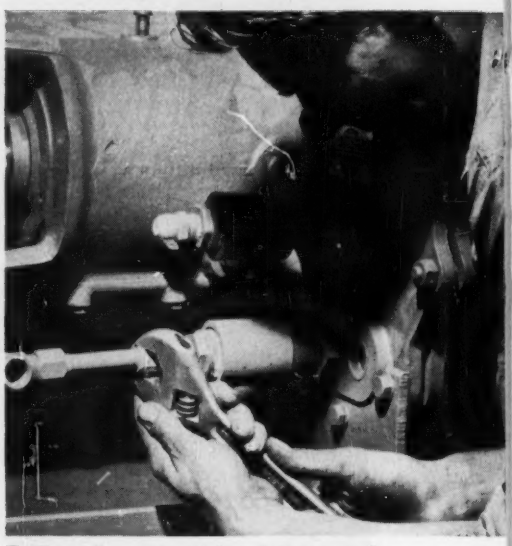
Why not take the bull by the horns and eliminate rinsing? Fill the boiler immediately with an alkaline solution to neutralize remaining acid and use sequestrants to tie up Ca^{++}, Mg^{++} and Fe^{+++}. Lab tests, calculations of amounts of materials show the method to be technically sound, economically feasible. It may even lead to other changes in conventional methods.

Can nitrogen blanketing be eliminated? what about boilout or passivation procedures—can they be changed to make the total job easier, more economical, better? There are many sequestrants and we have scarcely begun to use them. Their future should be intriguing and profitable for those who take full advantage of them.

Before you can get at the mechanical seal, you have to



1 Take out coupling spacer between pump and motor coupling flanges. Added space available lets you remove rotor and bearing assembly without touching motor or piping



2 Then disconnect piping between seal assembly and external heat exchanger

Mechanical seals are gaining in high-temperature-water pumps—they cut stuffing-box maintenance and conserve treated heating water. But if you want top service you do have to handle them with care. Let's see . . .

How to inspect and maintain mechanical seals in HTW pumps

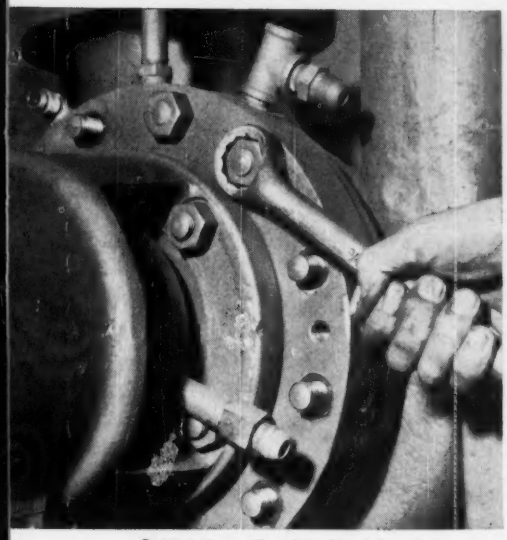
By J R BROCE, Worthington Corporation

As industrial and institutional heating continue to swing over to high-temperature water, the equipment involved needs close attention. While the heart of any HTW system is its pumps (POWER, Sept 1960, pp 88-89), successful pump operation depends largely upon good shaft sealing.

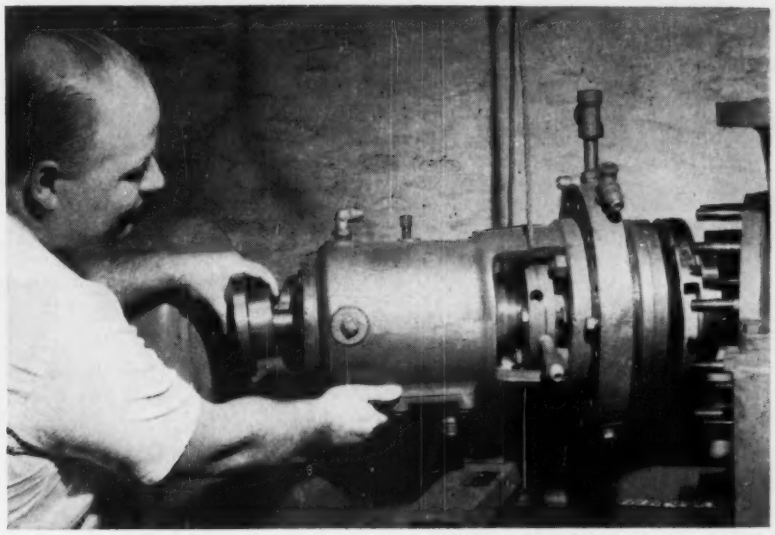
Mechanical seals make the sealing job easier for system designers and operators by drastically cutting shaft leakage and the need for continuous adjustment. But a mechanical seal cannot be classed as a garden-variety item; it's equipment of a high order built to very close tolerances, and for proper operation it requires careful installation. In hot-water applications, temperature control is a must. If the full operating temperature of the system is allowed to hit the seal faces, life is sure to be abbreviated and operating costs can climb.

What is a mechanical seal, and how does it work? Basically it consists of two parts—a rotating element fixed to the pump shaft or shaft sleeve and a stationary gland assembly. Rotating element consists of a collar, drive pins, compression springs, O-ring and seal ring (pumping ring

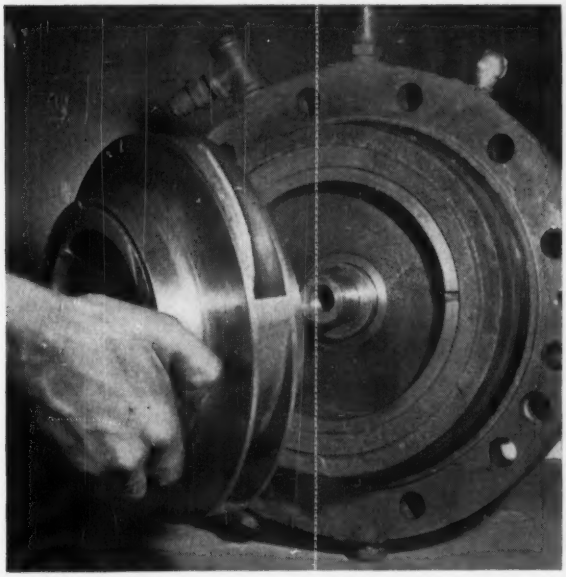
carefully dismantle circulating pump's liquid end



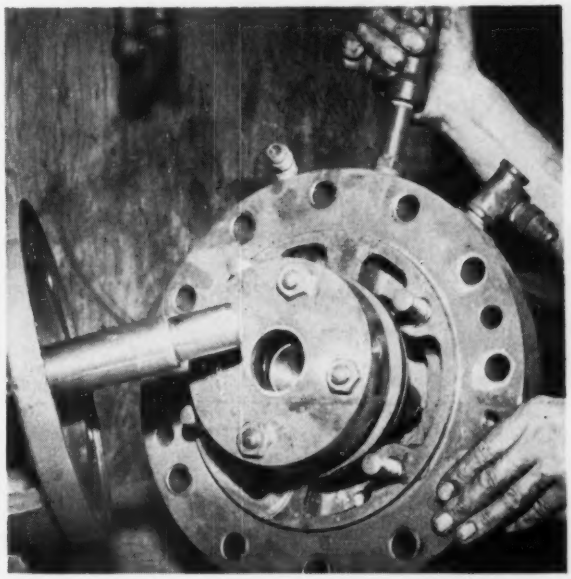
3 Unbolt stuffing-box head from pump casing. Use jack bolts to break this joint



4 Swing out rotor and bearing assembly. With coupling spacer out of the way you can clear casing studs and motor-shaft extension. Move to bench for further disassembly



5 Take off impeller nut and washer. Then pull the impeller, but be sure to keep track of the impeller key which may fall out



6 Separate stuffing-box head from bearing assembly. Doing this may also separate seal faces; use extreme care not to damage them

also rotates, of course, but it's not part of the basic seal element). Drive pins transmit torque from collar to seal ring. Compression springs maintain even face pressure between seal ring and stationary carbon insert. The O-ring is a stationary seal between collar and shaft or sleeve.

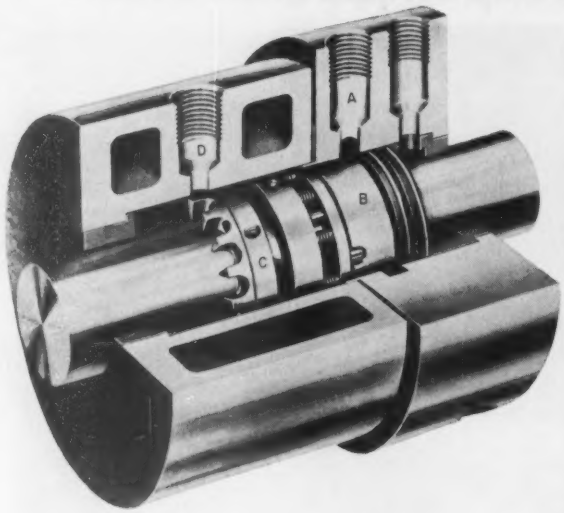
Stationary gland with carbon insert is fastened to pump casing by four bolts—this insures even bolt pressure and true gland position perpendicular to pump-shaft center line. The rotating seal ring, made of ceramic or tungsten-carbide, runs against a stationary carbon insert fitted into the gland to provide the positive sealing action.

Let's examine a HTW pump in operation. We want to see just how to get at the seal, inspect it and if necessary replace it properly. Photos on these four pages show the procedure in detail.

One last word: Precision equipment needs precise handling. Treat the seal assembly like the truly fine piece of workmanship it is. A sloppily installed seal can almost be guaranteed to fail right away. But a little care and skill make the job easy and assure good results.

continued

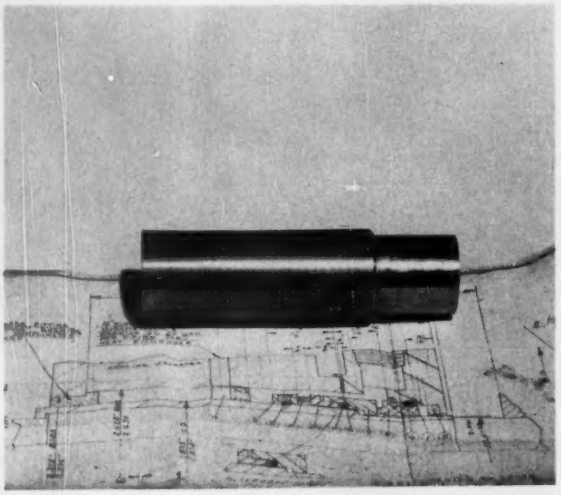
Check dimensions against manufacturer's drawing. Then



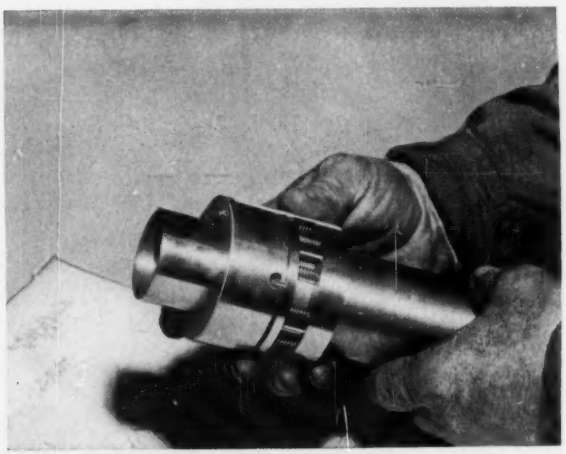
HTW seal cools itself

Seal faces in a high-temperature-water mechanical seal are protected by a built-in closed-circuit cooling system. Cool water enters seal chamber through inlet *A* and flows around seal assembly *B*. Pumping ring *C* provides circulation. Water then discharges to cooler through outlet *D*. Heat picked up during flow through seal assembly is removed by an external cooler and water returns to seal inlet. Throat bushing *E* restricts hot-water flow into seal chamber, in effect producing a dead end. Minimized heat flow cuts load on the cooling system.

In this design a rotating ceramic or tungsten-carbide seal face runs against a stationary carbon insert in the gland. Rotating parts—seal assembly and pumping ring—are accurately located axially by set screws. Be sure to use an *unhardened* shaft or shaft-sleeve material to permit proper set-screw action.



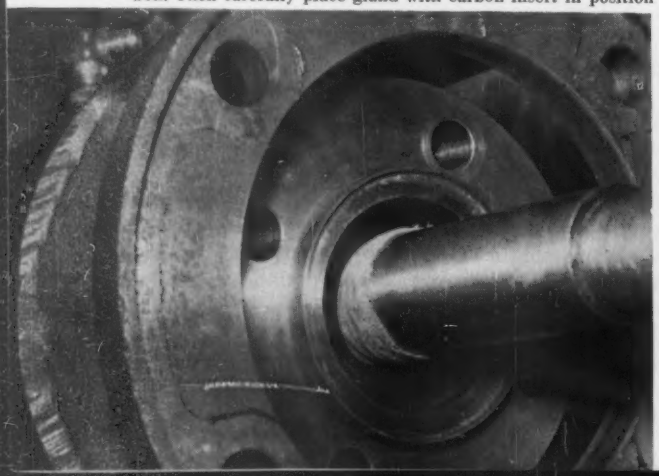
7 Check shaft sleeve against seal-assembly drawing to be sure that all dimensions are as called for and finish is right



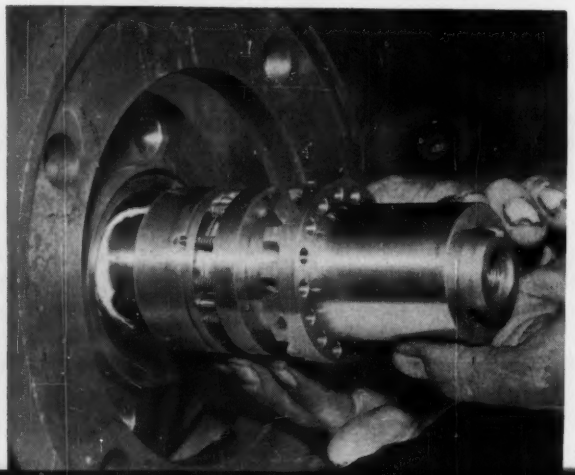
10 Carefully fit seal assembly over shaft sleeve. Be sure you don't distort the O-ring that seals between collar and sleeve

As you put the pump back together, handle all parts with

13 Cover shaft inboard bearing with soft paper to protect carbon. Then carefully place gland with carbon insert in position

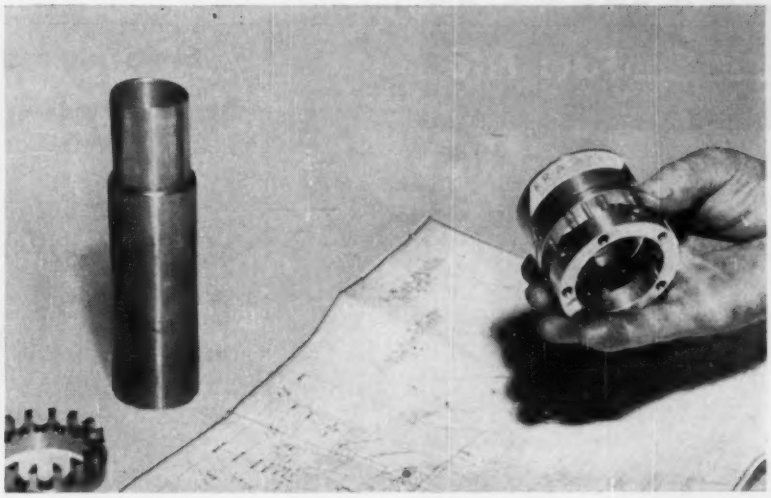


14 Place seal, assembled on shaft sleeve, over shaft extension. Don't disturb the setting and don't let the springs come out

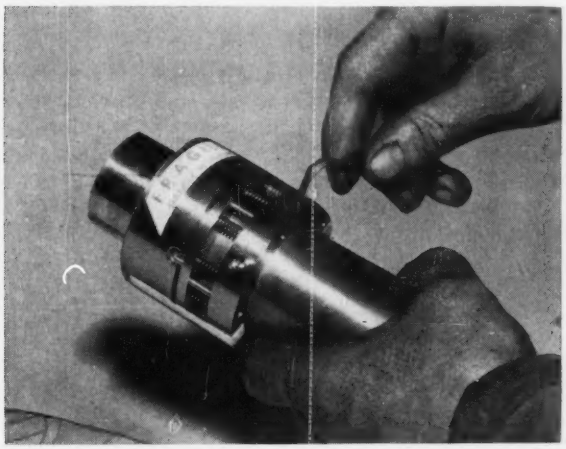


be sure you've reassembled the seal correctly

8 Scribe shaft sleeve to show location of parts — locations come from drawing



9 Check seal assembly—collar, springs, pins and rotating seal face—and pumping ring against manufacturer's drawing. Be sure that they are correctly put together

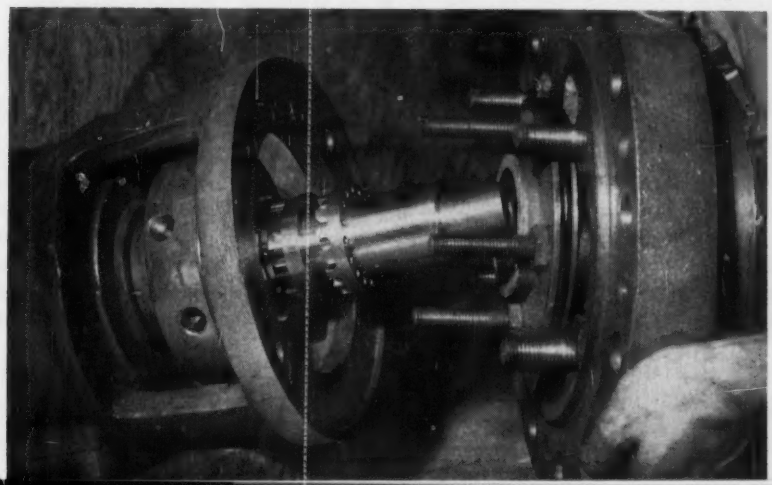


11 Locate seal assembly on scribed line. Tighten set screws to lock in position. Repeat this process with the pumping ring

12 Lightly oil seal faces to protect them while they're being assembled into the HTW pump and during the time before startup

extreme care to avoid damage to seal assembly

15 Carefully mount stuffing-box head over the positioned seal assembly. Be sure not to disturb seal adjustment or knock rotating seal face against carbon insert in gland



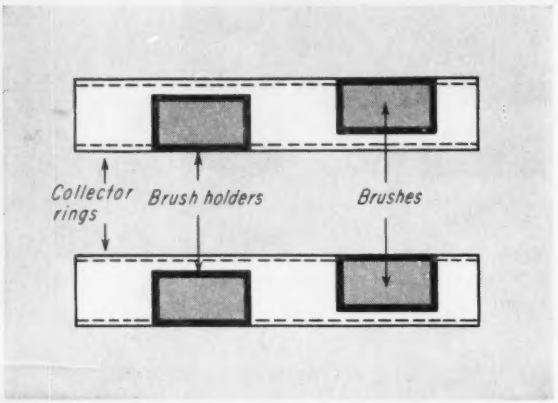
16 After bolting up stuffing-box head, position gland and tighten bolts evenly

Plant Electrical Fact File

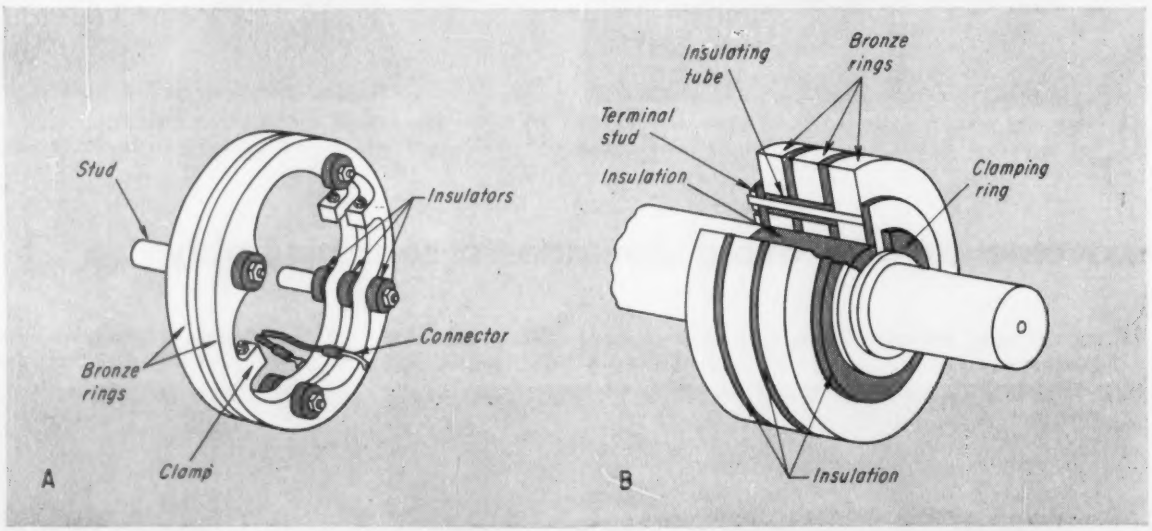
NO. 62: COLLECTOR RINGS

Collector rings need this care

By NORMAN PEACH, Associate Editor

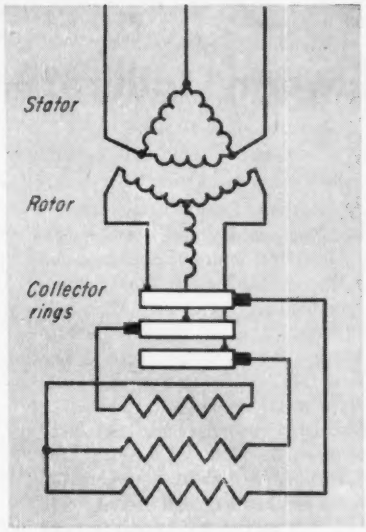


BRUSH-HOLDER arrangement affects ring wear. If possible, arrange brush holders so that wear distributes over maximum ring surface. In this way, the rings are less likely to groove or streak. If rings carry dc, occasionally reverse polarity of rings so as to avoid "plating" effects

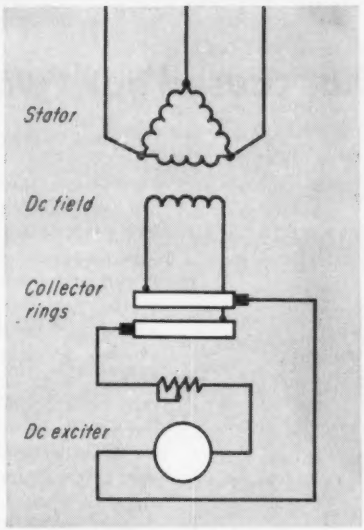


COLLECTOR RINGS or slip rings are constructed on two basic principles: stud-mounted, left, and compression, right. Larger rings are usually cast bronze, mounted on insulators supported on studs. Rings may be solid or made in two halves, clamped together as shown for a large synchronous motor. Wound-rotor motors are more likely to use some form of the compression rings. Devices shown above are held together by clamping rings and nut on a threaded shoulder of shaft. Solid insulation is used between rings and it's machined along with them. Simplest form of slip ring is shrunk onto an insulating sleeve on shaft, with space between one ring and next

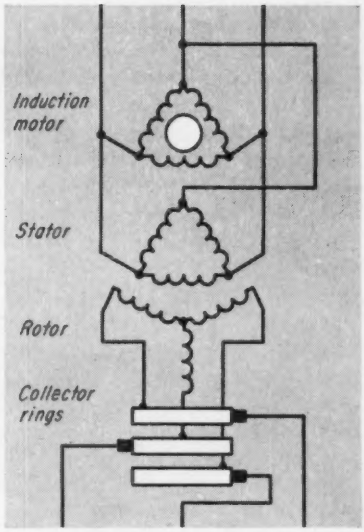
Rings are important on these machines



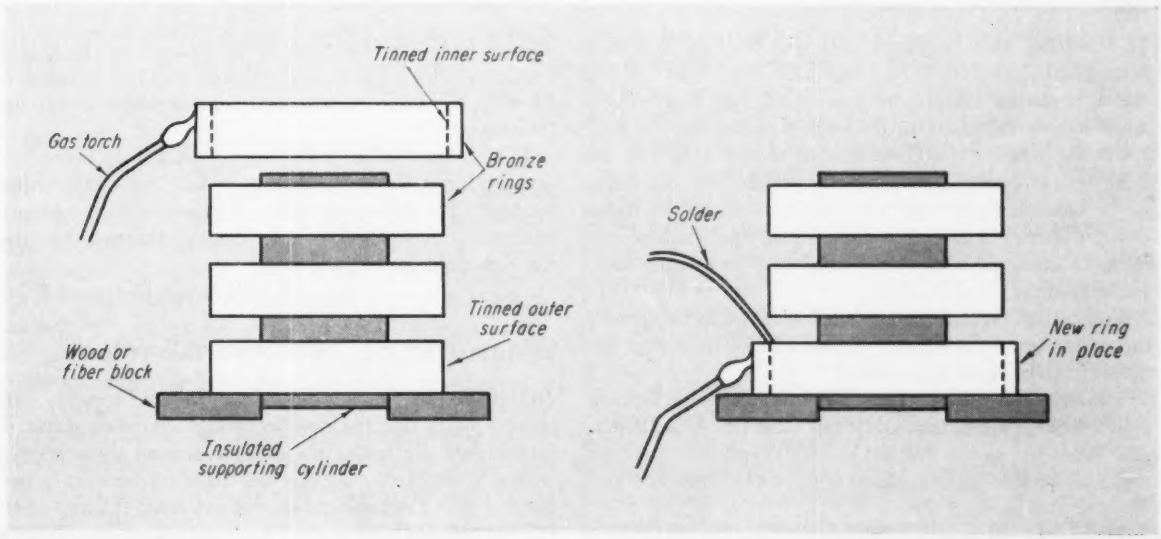
WOUND-ROTOR MOTOR has slip rings carrying rotor current of varying frequency. External resistors control motor speed, torque, starting current manually or automatically



SYNCHRONOUS MOTOR uses slip rings to supply dc to its field coils. Dc is small compared with line ac since it only supplies excitation. The dc is controlled automatically



FREQUENCY CHANGER has wound-rotor machine (same as motor) on output end. Output frequency depends on generator poles and speed (determined by the driving motor)



EMERGENCY REPAIRS on collector rings can be made as shown above, though whenever possible, rings should be replaced with new ones ordered from original manufacturer. Turn old rings down leaving rough cut; tin them thinly. Tin inside of replacement ring and use heat to expand it. Drop new ring over old one, applying heat and additional solder if necessary. Apply suitable blocking and repeat for next ring. When cooled, turn to proper diameter — and whenever rings are turned, tool marks should be dressed out so you get a fair polish. Keep entire structure clean, free of dirt, grease. Make insulation-resistance test with slip rings disconnected

These **plant problems** could well be yours...

What caused our "woodworm" failure?

Our plant has a small high-speed water-cooled industrial gasoline engine. After 1500 hours of operation the engine was taken off the line with rings broken from overheating. During overhaul we found two other failures shown in the photograph. First, there is definite evidence of erosion around the oil outlet. Second, the babbitt lining has been removed in an irregular pattern right down to bare metal. It actually looks like the ring has been attacked by woodworms. There was no other evidence of scoring. We used SAE 30 for about 1000 hours and SAE 10 W 30 with detergent for about 500 hours. I'm hoping readers can explain this "woodworm" failure and tell us how to prevent it from happening again—*EWT, August* POWER

Solutions...

Take more care when opening engine up

The bearing shell pictured and the description almost certainly indicate that old bugaboo, dirt. The bearing metal, probably a high-lead compound, has done exactly what it was supposed to do in protecting the crank of journals. When a piece of foreign matter gets into the bearing it causes local overheating which melts out lining of the bearing before any real damage is done, yet leaves enough bearing material to support the loads imposed on it. *EWT's* engine apparently continued to operate satisfactorily until overhaul time.

Preventing reoccurrence means more care in opening the engine up. As in so many pieces of close-tolerance machinery, cleanliness is essential.

Strainers and filter in the lube-oil system should be carefully checked, but if this job is not carefully done, it may add more dirt to the system. Double-check lube strainers and filters when changing from a noncompounded oil to a compounded one.

The wrong oil may also attack the bearing material in some cases. The material then has an etched or frosted appearance—I can't tell whether the photo shows this. Best course is to select a good, compounded, heavy-duty oil and stick to it. Use manufacturer's recommendations as a guide when making this decision.

EWT's trouble, including ring breakage, could have started with the change at 1000 hours from regular to compounded oil. The compounded oil was just trying to do its work, but it distributed accumulated sludge all through the engine.

If the cause of overheating is not known, check for plugged oil passages. Rings wouldn't necessarily break because of overheating. Were they stuck with excessive carbon? A close check of tolerances all through the cylinder assembly seems indicated.

J H GRAHAM, *Redmond, Wash.*

Bilgewater on "woodworm" failure

Babbitt in *EWT's* bearing shell melted (wiped), then was pounded into the woodworm configuration shown in photo. Just dig under the babbitt around these grooves with a knife blade and it'll peel right off because it isn't bonded with the babbitt that did not melt. If some of the babbitt had not been carried away with the lube oil, entire bearing would have filled up again and you would hardly know you had a failure.

What caused it? It's plain enough that the bearing overheated for one of a dozen reasons. Your guess is as good as the next guy's. Could have been some foreign particle stopping the oil supply for a moment, excessive

...Here's how *Power* readers would tackle them

BOB MARKS, Special Projects Editor

blowby of combustion gases and flame past piston rings while engine was overspeeding, oil temperature too high while overspeeding—hell, YOU name it.

How to prevent? Find the cause! Be sure to blow out all the oil lines in crankshaft, connecting rods, etc—or pieces of lost babbitt will again stop lubrication. Renew piston rings and hone cylinders.

If you don't believe my theory about your woodworm, read pp 184-185 of *Plant Operators' Manual*, McGraw-Hill Book Co, 1956. It's all in there, Son—plain as the bottle in your hand. MARMADUKE SURFACEBLOW

Detergent oil is the real culprit here

Any good automobile mechanic could have prevented *EWT*'s troubles of "woodworm" bearing failures. Detergent oil is the culprit here. After the inevitable buildup of sludge resulting from use of ordinary oil, *EWT* used the detergent. This oil cleaned out the engine and the sludge buildup on walls precipitated into the base where it successfully sealed off the bearings' lubrication ports. Bearings overheated and this fact plus possible sludge deposits picked up by the oil ruined the bearings. If the engine was originally new, it should have been first lubricated with HD oil, but HD should never be used in an old engine or one that has previously used regular oil—unless engine is thoroughly cleaned internally before the switch. There is no doubt in my mind that the oil switch was also responsible for broken rings, because of improper lubrication and resultant overheating. Before returning this engine to service, *EWT* would do well to check bore for concentricity, because damage may have been done to sidewalls. This will necessitate reboring and possibly oversized pistons and rings, depending on severity of overheating.

R A ROUSSEAU, *New Bedford, Mass.*

This looks like a stress failure

EWT's engine bearing shows evidence of fretting type of stress failure rather than any chemical or erosive attack. Since fretting is usually associated with shock loading or reversal of stress and since *EWT* is dealing with a gasoline engine which wouldn't normally subject its bearings to such attack, I suggest the possibility that his engine is incurring some form of early detonation. This may be caused either by excessive spark advance, use of too-low antiknock-rating fuel or perhaps high jacket temperature. Using a low-viscosity oil would aggravate this type failure but isn't normally its basic cause.

F G FEELEY JR, *New York, N.Y.*

Cooling-water supply may hold answer

EWT mentioned that the engine is water-cooled. He does not, however, state how this is accomplished. We have a suspicion which may or may not be true. It has long been a custom to cool small, stationary internal-combustion engines from the "house" water system. This is inexpensive and convenient since one needs only to connect a small supply line to the engine cooling-water system and a suitable waste line to a convenient drain. Engine temperature is generally controlled by throttling supply to the water jackets.

We found out the hard way, many years ago, that this is extremely poor practice. Engine water jackets are designed for a specific flow velocity. Obviously, if cold water is supplied and throttled to maintain normal operating temperatures, the flow velocity is a fraction of that for which the engine is designed. The end result is extreme hot spots within the engine, even though indicated temperature is normal. This results in *EWT*'s type of failure.

EWT's bearing also has the rather typical appearance of acid etching. It might have been the direct result of the ring failure that was the initial reason for inspection and overhaul of the engine. I suspect this failure was progressive, allowing increasing blowby that introduced higher than normal amounts of combustion byproducts. These possibly combined with moisture in the crankcase to create a sulfurous acid condition that etched the bearings.

J B MURPHY, *Peoria, Ill.*

Detonation is the source of trouble

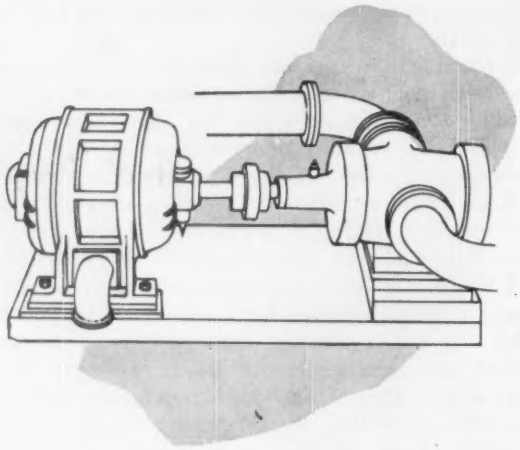
Clue to what happened to this bearing is found in the statement concerning broken piston rings. While *EWT* assumes that these rings broke because they overheated, it is far more likely that they were broken by detonation which could have either been the cause or effect of overheating. These are some possible causes of detonation: (1) ignition timing is over-advanced (2) distributor's automatic-advance mechanism is defective, causing failure of mechanism to retard spark under load (3) carburetion is too lean (4) spark plugs' heat range is too high; their insulators glow and cause pre-ignition (5) constant-speed and -load operation causes glowing head deposits.

Detonation in the engine would cause a fatigue failure in the bearing at or near the TDC position of the upper bearing shell, which is borne out by the picture of this bearing. It would therefore appear that *EWT* should look for the solution to his bearing failures in the combustion chamber rather than in the crankcase.

There is another cause of this type of flaking in a bearing, and it's frequently overlooked because of failure to examine the bearing properly. This flaking is caused by dirt between the rod and the bearing insert. It can readily be identified by looking for black spots on the back of the insert opposite the flaked area of the lining. If a bearing is fitted cleanly and properly to the rod, the back will have a uniform grey color when wiped with a dry rag.

H B MINICK JR, *Atlanta, Ga.*

Want some help on plant problems? Send us any of your design or operating headaches for *Power* reader comment



How can we reduce gear-pump wear?

In our plant we have four rotary gear pumps operating on liquid ammonia. They take suction from a low-pressure receiver and pump ammonia to various locations throughout the plant. These pumps went into operation last February and since then we have been replacing gears almost as fast as purchasing gets them on order. We believe that the lubricating properties of liquid ammonia are not good enough to prevent these gears from running together and wearing. The pump designer doesn't agree, but doesn't seem to have a solution, either. Perhaps some reader can tell us the reason behind this excessive gear wear and suggest how we can increase gear life.—*JW, August* POWER

Solutions . . . Start with this 4-point check list

JW should immediately submit to a lie-detector test (preferably with his boss absent!) and must be prepared to answer the following questions in the affirmative:

1. Did I purchase my pumps from a reliable manufacturer and are they designed for ammonia service? They should be all-iron construction with the gears of alloy iron. The gear-within-a-gear type of pump is preferred over the other designs. Rotor speed should be 400 to 500 rpm to reduce wear.

2. Are my pumps properly installed? Improper alignment causes excessive strain on the casing and contributes to gear wear. The piping must be well supported and flexible connectors installed if necessary.

3. Does my pump bypass valve discharge back to the storage tank? A built-in pump bypass valve discharging directly to the pump inlet will cause heat buildup with consequent vapor formation, decreased pump efficiency and increased wear. Best hookup discharges back to the tank directly. A separate hand-operated bypass valve for pump startup is also desirable. The main bypass valve should be set 15- to 20-psi above the rated differential pressure of the pump and the recirculation rate kept to a minimum.

4. Is my suction piping well designed? In order to have an ideal pump installation so that the pump handles all liquid and no vapor, the pressure drop in the piping must be equal to or less than the static head on the pump inlet. This means that the storage tank and therefore the liquid level must be high enough above the pump so that the height of liquid can offset friction loss in the piping, valves and fittings (not forgetting the excess-flow valve located at tank outlet!). Moreover, suction piping must be short and have no high points where vapor binding could permit pump to run dry. A 40-mesh strainer must be installed (no copper or copper-bearing alloys!) in the suction piping to keep scale and other foreign material from damaging the pump gears.

To suggest hard-facing the gears with stellite is like sending good money after bad, since this is not getting to the root of the problem. Pumping liquid ammonia with gear pumps is common practice and a well-designed system should give its operator no serious problems.

D G LAW, *Shawinigan, P.Q., Canada*

Piping-system design may be in error

Let's concede that the designer knows his stuff and the pump is all right for pumping liquid ammonia. Let's assume that the assemblers did not mess things up by putting copper-alloy parts into the pumps which were dutifully replaced with more copper when worn.

Conceding this, it would seem that the pump trouble is only an indication that there is an error in piping design. With no information to the contrary available, let's assume that liquid ammonia leaves the condenser with a few degrees of subcooling. If suction piping leading to the pump is long—or, perhaps, small enough to cause the re-

frigerant to travel at high velocity and large pressure drop —there is an excellent chance for refrigerant to flash into vapor. Perhaps not enough vapor to bind the system, but more than enough for some vapor to displace some ammonia liquid and keep it from lubricating gears of the pump. Failure is inevitable.

JW should check temperature and pressure of ammonia near pump's suction side. If pressure is too low for temperature of the liquid he should subcool the liquid or create a hydrostatic head on pump suction.

JOHN BELUNAS, *Wyoming, Pa.*

Check design and operating conditions

Many plants use gear pumps to recirculate liquid ammonia under continuous, heavy-duty service conditions. My bet is that operating or design conditions are at fault here rather than the pumps themselves.

Pump installations on volatile liquids often fail because suction conditions are not properly evaluated. The liquid ammonia in the receiver is probably at boiling temperature at the low pressure involved. In order to prevent liquid from vaporizing in the suction line and inlet side of the pump, the fluid system must be carefully designed to allow sufficient hydraulic head with adequate venting of gases back to the receiver. The situation is analogous to that of a boiler-feed pump taking suction from a deaerating heater or a condensate pump on a condenser hotwell. In the case of ammonia the situation is aggravated by the low temperatures involved. Any heat losses are invariably from ambient to the liquid ammonia, tending to vaporize liquid in the suction line. Probably an improperly designed suction side produces more operating difficulties than any other single cause.

In starting, especially, the pumps may be vapor-bound. Make sure vents are opened and the pump allowed to fill with liquid before starting.

Another point, which is neglected in a surprising number of installations, is liquid level in the receiver. Make sure it is actually at the desired height. On a multievaporator system there may be severe fluctuations in receiver level. Be sure the receiver has sufficient capacity to take care of any sudden load changes.

In a new system, piping and equipment should be thoroughly cleaned and flushed to remove foreign matter which might injure pumps and plug header orifices where downfeed coils are used.

I recommend installation of a suction strainer, to be used only at startup or after any changes are made to the system. After the piping and vessels are thoroughly flushed and charged with ammonia, run the pumps for 24 hr or more at full capacity. Keep temperature of ammonia at a moderately high level, say 30 F or above. If an inspection of the strainer basket indicates that the system is thoroughly clean, remove the strainer and set it aside for future use. One word of caution: fine-mesh strainers at low temperatures may get plugged with chilled oil to the point where the pump suction flow is definitely impaired.

IRBY HICKS, *Ferndale, Wash.*

Your December problems

What's best way to handle small-plant maintenance?

Our plant has 65 employees engaged primarily in the manufacture of cable and flexible conduit. We have about 40,000 sq ft of space and needless to say, maintenance time and labor are very much at a premium. Mechanical maintenance has not posed much of a problem. But we are having trouble coping with electronic controls, motors, power distribution and switches. Our plant has well over 150 motors of varying sizes and types from fractional up through 75 hp.

How should we organize our electric-maintenance program? What about preventive maintenance? What spare parts should be stocked? How can we best manage maintenance paperwork and records? I'd like to hear how other POWER readers handle this problem in their plants.—*WLH*

How can we clean up conditioned air?

Although our plant is now over ten years old it is completely air conditioned. Dust must be kept out of work areas because it spoils manufactured goods, increases rejects. Manufacturing spaces are divided into a small number of rooms served by supply and return ducts running from large plenum chambers in the basement.

Air is supplied by two fans with air washers. The fans take in fresh air from above the building roof. We use standard filters in all air intakes.

We are getting a rash of complaints from manufacturing areas about large quantities of dust entering the various rooms. We've tried several schemes for removing dust from the ducts, but none has worked well. What is the best way to handle this problem?—*SG*

Sit down right now and answer one or both problems. We'll pay extra for answers with photos or sketches

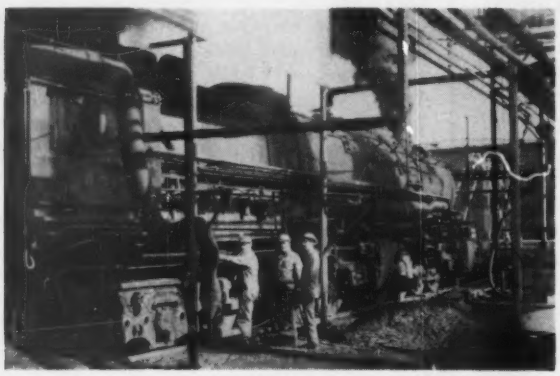
Consider reducing gear-pump speed

Spur-gear pumps are susceptible to fluid-trapping troubles. Even with some of the built-in hydraulic balancing features, problems become pronounced at higher rpm. Therefore, a suitable reduction in rotative speed may improve service life considerably. Also, while spur and helical gear pumps are generally reversible, herringbone gear pumps are not.

When running in the wrong direction, fluid is trapped in the V and the mating gear rolling in on the pocket sets up severe stresses. With corrosive chemical fluids this tends to break down any thin protective coatings which form over metal surfaces wetted by the fluid. Corrosion-erosion sets in and disrupts this surface, separating the fluid film and the mating gear teeth.

EMIL WITTMANN, *Villas, N.J.*

Timely **practical ideas** to help solve



Iron horse to the rescue, generating steam from gas

Repairs to existing steam generators were going on and a new boiler being installed—we needed lots of extra steam at our Moundsville plant, and in a hurry. The B&O RR came to our rescue with two steam locomotives.

We parked the iron horses on an idle track nearby and installed a collector header. It connected the steam-dome discharge manifold of each locomotive to the plant steam main. We ran in a feedwater header to supply treated water from the plant boiler-feed pumps.

We tried burning crushed coal on the steam-operated stokers but that produced smoke, soot and flyash. So, since we had 100-psig natural gas available, we decided to make up two sets of twin-barreled gas burners. The 2-ft-long 8-in.-dia-pipe burners expanded the gas fully when it was injected into the burners with supplementary air. Gas-injection-nozzle orifice caps were machined from standard 1-in. pipe caps. We tested these burners before installing them.

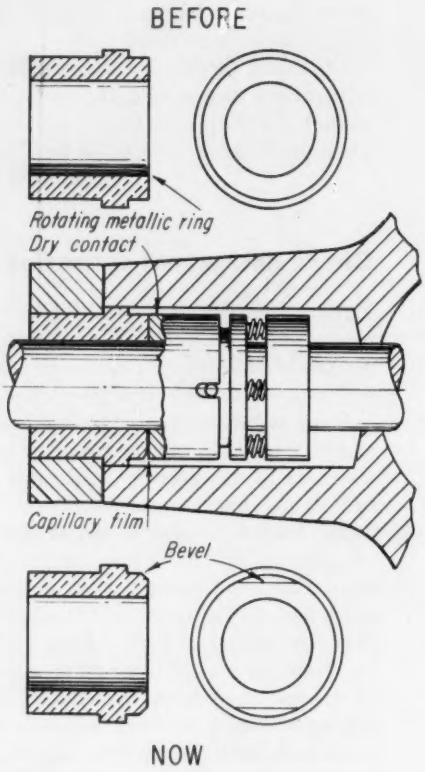
The locomotive fireboxes had to be prepared for gas firing by laying firebrick loosely but closely over entire grate area. Then a firebrick "blast" wall, 3-ft high, 5-ft wide and 18-in. thick, was constructed 6 ft from the firebox entrance and perpendicular to the burner axis. This wall kept flame from blasting directly onto the tube sheet. It also provided a permanent incandescent surface during operation to prevent flameout.

An automatic valve was placed in the gas feed line before each set of twin burners. This valve would close on impulse from a flame-failure signal in case of flameout or from a pressure switch if main pressure of the gas dropped below a safe limit. We then installed the twin burners in the firebox door, ready to go.

Those two iron horses worked faithfully from Feb 15, 1960 to April 15, 1961. After we'd converted them to gas, we chalked up a fuel saving of $15,000 per month based on an actual production rate of 430 net tons of steam per day. Savings came from less labor and increased firing efficiency. There was no smoke, soot or flyash.

Once the job was done, the two locomotives were sent to the salvage yard as scrap. But they ended their days giving faithful service.

T H Capps, *Allied Chemical Corp*



Altered seal ring shortens run-in time

Surface lubrication was lacking between seal faces at the initial run-in of inside type mechanical seals on our centrifugal gasoline pumps. This was the chief reason why they scored and failed. Gasoline was sealed on the outside of the rotating seal ring, so the liquid tended to work away from the seal face. This, combined with perfect flatness, brought the faces into contact at time of installation. No gasoline could seep between them so they were left dry. Seals failed, of course.

To help form a fluid film, we beveled the stationary carbon ring on diametrically opposite sides, sketch. Stationary ring absorbs layers of gasoline on the wetted exposed part of the metallic rotating ring. Liquid is spread over the entire face and helps to build up the gap so capillary attraction can take place. As a result, seals now behave as they should from

Now, you have a reason . . .

to visit our big green building when you're next in Manhattan. The large new book store in the lobby is one of the most complete in the world—*all* publishers' books are handled. Bring your family to see the new science books for kids. We're located one short block from Times Square.

STEVE ELONKA, Associate Editor

the time of installation, as though they had been run in for a long time.

E WITTMANN, *Villas, N. J.*

EDITOR'S NOTE: Just as E Wittmann's letter arrived, we were discussing mechanical seals with Harry Tankus, Chief Engineer of Crane Packing Co. We showed him the before-and-after sketch—these are his comments:

"There is some experimental work being done on so-called beveled or cut-out faces, but not for the purpose indicated in this sketch. It is more for balancing effect on extremely high pressures and poor lubricants.

"I'd like to know what the stationary-seat material is and what pressure this seal had worked in. Perhaps a balanced seal could have helped.

"We prefer symmetrical faces on balanced seals rather than fancy configurated faces because the cut-out portion of the face allows foreign materials to get at these areas, sometimes creating abrasive hazards. Once we have a set of symmetrical faces 'married' we like to keep them that way, rather than start divorce proceedings with the foreign materials as the correspondent.

"It is true that we lap to within a few light bands, but even at that, the softer member (usually carbon) mates against the harder member. While this is *called* run-in, it usually reflects comparatively few revolutions."

What would you have done?

Years ago I was chief engineer of a small laundry on a river bank. The place was completely isolated from the city streets. It had a good cover of trees and lush green lawn.

I had to make a cold start one Monday at 4:30 am. Since I always left the stack cleanout door open to kill the draft after shutting down on Saturday, the first thing I did was close and latch it.

I soon had a waste and wood fire going. Then suddenly I heard faint calls out along the river bank. But I paid no attention as this was a favorite spot for early-morning eel fishers. After the coal was lit and steam rising, I retired to the riverside for a thermos of coffee and a few quiet moments before oiling up and turning over the engine.

Did I say "quiet"? Looking up at our 50-ft stack, I was horror-struck: hanging to the top of the stack was the sorriest, dirtiest, most woebegone tramp I had ever seen. I tried to calm him, yelled I'd kill the draft and then he could come down the internal ladder.

But the derelict raved he'd jump if I didn't get him off immediately. And all I had was a 20-ft ladder.

Finally I tried some psychology. I placed the too-short ladder against the stack, telling the poor fellow that I would fetch the other half and have him safe in a minute. A quick call to the Fire Dept brought the aerial ladder and safety net. Our friend was promptly rescued. He had mistaken the inside base of the stack for a warm, quiet sleeping-off haven after his previous night's bender. What would *you* have done?

P S FINNERAL, *Lowell, Mass.*

Here's what I would have done . . .

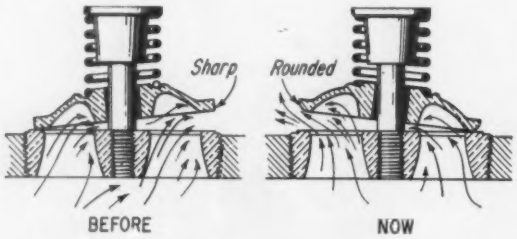
in W B Laughinghouse's place (Sept 1961, p 219). It seems to me he risked his ship, the way he repaired that skin valve. Why didn't he send a man over the side with a large rubber gasket and a collision mat to hang over the opening to the valve? Pressure of the sea water against the mat would have sealed the opening tightly. Then Laughinghouse could have ground the valve in without getting wet.

C M BECK, *Camas, Wash.*

EDITOR'S NOTE: *Yes, but who would tie the bell around the cat's neck? This valve opening was 27 ft below the water surface; it had over 11-psi pressure on it. I'm sure it wasn't practical to send a man over while under way, although perhaps a collision mat could have been used to seal that opening without endangering a man.*—STEVE ELONKA

Do you talk too loud?

In our research on noise isolation, we keep running across problems of distraction caused by people who talk louder than necessary. The accoustical engineers suggest everything from staggering doors along hallways to prevent "cross-talk" problems to putting a muzzle on the offenders. But why go to these extremes? Isn't it simpler to instruct new employees to talk so only the person they are addressing hears, not the whole office? Besides, common courtesy demands it.



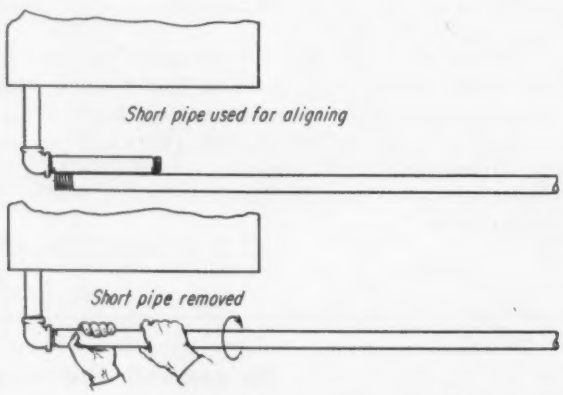
Our pump valves stay leakproof longer

Valves in the liquid end of our bronze-fitted duplex steam pumps didn't last long. The pump had hard usage from increased demand. Valves opened and closed with a tilting and oscillating action more or less at the will of the pressure and turbulence of the liquid (clearances are shown exaggerated in sketch).

Disk's edge roughened the surface of the seat, causing unequal wear of the mating surfaces. This killed the valves. We were always having to take the pumps out of service so their valves could be reseated. The excessive downtime cost real money.

To avoid this, we now round the circumferential edge of each valve disk. There is less tendency to roughness and wear. Action of disk upon seat tends to work-harden the rounded edge, producing a thin work-hardened layer on the seat surface—a wear-resistant layer which does a good job. Now our valves stay leakproof much longer, reduce maintenance.

E WITTMANN, *Villas, N.J.*



Here's how we line up long lengths of piping

Connecting long lengths of threaded pipe often becomes a problem. My sketch shows an idea that saves time and frayed tempers when you're trying to connect a long pipe to a fixed section, working overhead or through a wall.

Let's say you are trying to start the threaded end of a 2-in. pipe that is 10 to 20 ft long into a 2-in. fixed elbow. First, take a short length of 2-in. pipe, 2- or 3-ft long, with either one or both ends threaded. Screw the pipe into the elbow, hand tight only, sketch. Then bring the long length up to butt square against the short length. You may have to turn the elbow to get a square butt.

Keeping the long pipe in the same plane, move it back far enough so you can remove the short length of pipe. The long pipe will now start into threaded elbow without any trouble.—G M PRISKE, *Bourlamaque, Que.*

Big boner

During the war I was an operating engineer in a West Coast shipyard. This was an easy job so we accumulated quite a crew: an expoliceman, exbarber, exfarmer and quite a few exnobodies. Due to seniority, some of these fellows had got to be supervisors and were touchy about suggestions for improving a job.

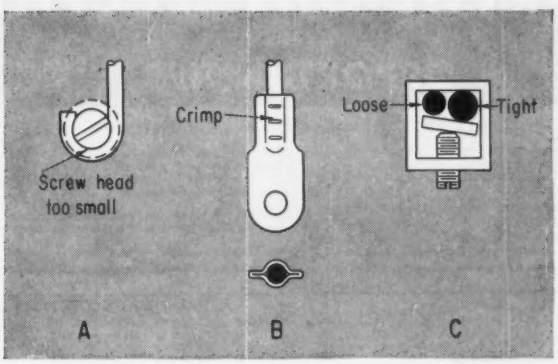
One night we had just completed boiling out two boilers aboard an aircraft carrier. A steam reciprocating pump had been temporarily hooked up to circulate the water in the boiler. There was a hurryup on as the carrier was needed.

The assistant foreman and his crew were trying to get the pressure off the boiler. They would crack a union on the pump and at 150 psi the hot caustic water would spray all over. I warned them a couple of times that this wasn't safe. I predicted someone would get hurt.

Finally I couldn't stand it any longer. I went to the sick bay to have my infected eye washed by a pretty blonde nurse. Returning an hour later I saw a crowd around the gangway. The whirley was just letting down someone on a stretcher. We crowded to see who had got hurt. It was a young fellow from our crew.

We hurried below to the engine room and found out what had happened. Two of our men had been working together. This young fellow was sitting on the grating beside the economizer header while the second man knocked in the handhole plate. Hot caustic water sprayed all over him. Fortunately he was not seriously burned—but he never returned to "easy go," either.

K M WHITE, *Chamois, Mo.*



PRESSURE ON THE SCREW will force a large wire from under it, *A*; proper crimping, *B*, holds wire tight. If wires are different sizes, the smaller will work loose, *C*, unless you've twisted them together before installation

Here's why you must firm up those loose connections

By M SHERRITT

Screws and wires must be installed properly if they're to give good service. Only too often, costly electrical and mechanical troubles trace back to nothing more than a loose connection. Three cases in my experience show how such a trivial oversight can lead to real problems.

I installed a flooded refrigeration system at a new ice-cream plant. Management wanted it ready for the next day. System had been checked out and was ready to go, but since the weather was very hot I had hoped for a couple of days to pull temperatures down. On the other hand, compressor and condenser were oversized for future expansion and evaporator coils had needed capacity, so there was no good reason for delay. I thought the system would cut off on high head for a while.

Four hours after I started the system it had pulled down to 50 F, cutting out on pressure only three times. Everything was shipshape when I went out to lunch. But as I neared the plant after lunch I smelled ammonia, then saw a white plume around the safety-valve discharge.

I found the head-pressure gage at 290 psi, although high-pressure cutout was set to open at 225 psi. I pulled the disconnect, then checked the high-pressure switch. It was open, but even with juice off, the motor starter was still in operating position. Investigating, I found that an unused terminal screw had vibrated loose and fallen into the switch, thus preventing the contactor from dropping open.

A second plant had a 100-hp Hrt gas-fired boiler with float type high-low-water control and electric boiler-feed pump. The fireman called me one morning: there was no water in the gage glass, the fusible plug had blown and he had found the burner still operating when he returned from his regular plant rounds.

I found the float had dropped quite far enough to call for water, but a piece of scale prevented it from dropping low enough to shut off the burner when it didn't get that water. An unused terminal screw in the pump starter had come loose and lodged, holding a contact open. Then the pump motor had tried to start single-phase and kicked out the overload relays. Fortunately, the insurance company only had to replace two top rows of tubes.

I was once roused from bed at midnight by the office porter. He had seen smoke coming from the lighting panel. As he pulled the main breaker, he saw a glow behind the panel. Then there was a pop and every light in the plant went out.

On removing the cover from the panel, I found a main terminal burnt from the mounting and fused to the box. This ground had blown the main light fuse for the entire plant. The mounting was severly carbonized where the terminal had been, and the other two terminals showed the beginning of carbonization and overheating. I gave a light tug on the cable and pulled it loose from its lugs! The panel was only a few months old and hadn't been overloaded—another case of failure because connections weren't tightened properly.

Electricians may forget to tighten wires, or they may not tighten them enough. Stranded wires above No. 10 must be worked back and forth when you're tightening lug screws; larger sizes should be pounded with a rubber hammer. If this isn't done, normal vibration causes the wires to loosen, producing heating, oxidized contact surfaces, low voltage—and sometimes ruined apparatus.

Here are some other do's and don't's for electric connections: Except in very old apparatus, terminal screws won't take larger than a No. 12 wire. Sketch *A* shows how pressure on the screw will force a large wire from under it. Normal vibration, too, will work it loose. So make connections with solderless lugs. Avoid use of solder lugs —if you must use one, install it as in sketch *B*, with sides crimped tightly against wire, then crimped several times crossways. That makes a good mechanical and electric contact.

Don't insert wires of different sizes or solid and stranded wire side-by-side in a lug—twist them together first. In sketch *C*, the larger wire is clamped, but the smaller wire is loose.

If you tighten all screws firmly, if you make connections properly and if you never call a job finished until you've checked all connections, you'll save costly headaches. And it's a good routine, whenever you have the cover off a switch, to check all connections for tightness. Do it every time.

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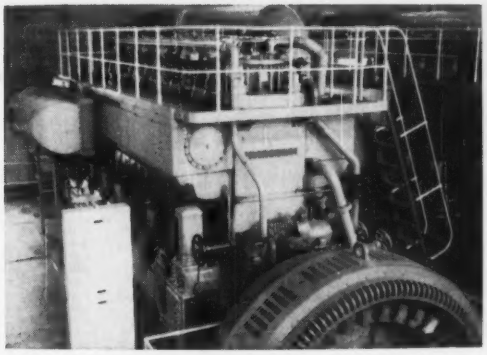

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625 KW, West. Non-C. Turbo-Gen. 3/60, 480 V., 3600 RPM, 200 PSIG, 5-12 PSIG exh.
1000 KW, G.M. 16-278A, Diesel Units (2) 3 ph. 60 cycle, 2300 V., 720 RPM.
750 KW, G.M. 12-567A, Diesel Units (3) 3 ph. 60 cycle, 2300 V., 720 RPM.
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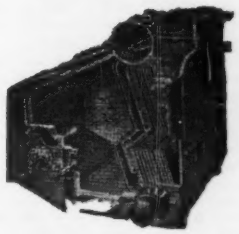

#Steam/hr.	Key	PSI	Temp.
122,500	DF	565	850
121,650	DF	565	850
60,000	SF	435	750
74,000	H	280	500
55,000	A	240	—

DF Double Furnace, SF Single Furnace (Illustrated), bent water tube boilers w/economizers and superheaters, B & W's and Foster Wheelers.
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53 YEARS SERVICE

AC MOTORS: 3 phase 60 cy SLIP RING

Qu.	HP	MAKE	TYPE	VOLTS	SPEED
1	1750	G.E.	M-570BS	4800/2400	1800
1	800	WHSE.	CW	550/2300	1776
1	600	WHSE.	CW-32D	440	1778
1	600	WHSE.	CW	440	850
1	550	WHSE.	CW	440	252
1	500	WHSE.	CW	2300	881
1	500	WHSE.	CW	550/2300	350
1	300	AL. CH.	ANY	2200	720
1	300	GEN. EL.	MTP-561	2300	1760
1	300	GEN. EL.	M-568	440	720
1	250	CR. WH.	29Q	2300	850
1	250	GEN. EL.	IM	220/440	875
1	200	GEN. EL.	IM	440	435
1	200	GEN. EL.	IM	2200	580
2	200	WHSE.	CW-800	2300	1775

SQUIRREL CAGE

Qu.	HP	MAKE	TYPE	VOLTS	SPEED
3	1500	G.E.	K.D.P.	2300	3580
2	600	WHSE.	CS-1216	440	600
2	500	WHSE.	CSP-583H	D.P. 440	3600
1	500	AL. CH.	ARW-D.P.	2300	3600
3	500	WHSE.	CS-1216	2200	500
1	400	AL. CH.	AW30C86, D.P.	440	1770
1	400	WHSE.	CS7151	6600	3565
1	300	CONT.	NY686, D.P.	440	1780
1	250	WHSE.	CS-875S	2300	1775
1	200	WHSE.	CS-355S	440	1750

MOTOR GENERATOR SETS

Qu.	KW	MAKE	RPM	AC VOLTS	DC VOLTS
2	4800	G.E.	450	2300/4600	250/300
1	2500	WHSE.	720	2300/4160	600
1	2100/2400	G.E.	450	2300/4600	250/300
2	1750/2100	G.E.	514	2300/4600	250/300
1	2000	G.E.	514	2300/4600	600/666
1	1500	G.E.	720	13200/6600	600
1	1250	WHSE	720	2300/4000	600
1	1000	G.E.	900	2300/4000	600
1	1000	G.E.	900	6600/4000	200
1	1000	G.E.	720	2300/4000	275
1	500	G.E.	900	2300/4600	250
1	500	G.E.	900	440	250/125
3	300	G.E.	1200	2300	275
1	300	WHSE.	1200	2300/4160	600
1	300	G.E.	1200	2300/4160	250

FREQUENCY CHANGER SETS

Qu.	KW	MAKE	FREQ.	VOLTAGES
1	12500	WHSE.	60 To 25	13200-13200
1	5000	G.E.	60/50/60	11000-6600
1	2500	G.E.	60/24/60	2400-2400
1	2000	G.E.	60 To 25.7	4600-11000

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A. C. MOTORS—60 CYCLE

HP	Mfr.	Type	Volts	Speed
900	Whse. (2)	Sq. Cage	2300	1800
750	El. Machy.	Synch.	480	514
700	G.E.	Slipring	2300	400
700	G.E.	Slipring	2300	514
600	G.E.	Synch.	2300	514
600	G.E.	Synch.	480	900
600	Elliott (2)	Sq. Cage	2300	900
600	Whse.	Slipring	2300	360
500	G.E.	Slipring	2300/4000	514
500	G.E. b.b. (2)	Synch.	2300/440	1200
450	Allis Ch.	Sq. Cage	2300/440	720
400	G.E. Vertical	Sq. Cage	2300	720
400	Allis Ch.	Slipring	2300	900
400	Whse.	Sq. Cage	2200	514
400	Marathorn (2)	Sq. Cage	2300	3600
400	G.E.	Slipring	2200/440	600
400	Whse.	Sq. Cage	440	1200
350	Allis Ch. (2)	Slipring	2300	450
350	G.E.	Slipring	440	900
350	El. Machy.	Synch.	2300	900
300	G.E.	Slipring	220/440	514
250	G.E.	Sq. Cage	440	1200
250	Gen. Elec.	Sq. Cage	440	3600
250	Whse.	Sq. Cage	2300/440	600
250	Whse. (4)	Slipring	2300/440	600
200	G.E.	Slipring	550/440	1200
200	Allis Ch. TEFC	Sq. Cage	440	900
200	G.E.	Slipring	220/440	450
200	G.E.	Slipring	440	600
200	G.E.	Slipring	2200	900
200	Reliance b.b.	Sq. Cage	220/440	1800
200	Allis Ch.	Slipring	2300/440	720
200	G.E.	Sq. Cage	2300	450
150	Whse. b.b.	Sq. Cage	440	1800
150	Whse. XP	Sq. Cage	440	3600
150	G.E. (4)	Slipring	2300/440	600
150	Whse.	Slipring	220/440	1200
150	G.E.	Sq. Cage	2300/440	600
125	Star b.b.	Sq. Cage	220/440	900
125	A.C. TEFC	Sq. Cage	220/440	1800
125	El. Machy (3)	Synch.	220/440	400
125	G.E. TEFC	Sq. Cage	2200	3600
125	Al. Ch. TEFC	Sq. Cage	220/440	600
125	G.E. (2)	Slipring	220/440	514
100	L. Allis TEFC	Sq. Cage	440	900
100	Star b.b.	Sq. Cage	220/440	600
100	Allis Ch.	Slipring	2300/440	600
100	G.E. TEFC	Sq. Cage	220/440	1200
75	A.C. TEFC	Sq. Cage	2300/440	1200

D. C. MOTORS

HP	Mfr.	Type	Volts	Speed
350	G.E.	MPC	550	900/1200
250	Cr. Wh.	101-E	230	1150
200	Whse. b.b.	SK	250	287/575
150	Rel. TEFC b.b.	2550-F	230	850
125	G.E.	CD-173	230	575/1150
100	Reliance b.b.	1050-T	230	600/1200
100	Elliott b.b. T.E.	JH-FE	230	1150
100	El. Dyn. b.b. (2)	30-S	230	450/1200
75/100	Whse.	SK-191	230	300/900
60	G.E. TEFC b.b.	CD-135	230	1150
40/50	Whse b.b.	SK-173	230	300/1200

MOTOR-GENERATOR SETS

KW	Mfr.	Input	Output V
600	Allis Ch.	440 AC	250 DC
300	G.E.	440 AC	250/350 DC
250	Whse.	2200/440 AC	250 DC
200	Whse. synch.	220/440 AC	55 DC
200	Gen. Elec.*	220/440 AC	125 DC
125	Gen. Elec.	2300/4000 AC	250 DC
100	Delco b.b.	220/440 AC	120/240 DC
75	Whse. Synch.	220/440 AC	250 DC
75	Elec. Prod.	220/440 AC	125 DC
50	G.E.	220/440 AC	250 AC

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MO nroe 6-7409
1435 W. RANDOLPH ST
CHICAGO 7, ILLINOIS

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TRANSFORMERS—60 CYCLE

QU.	KVA	MAKE	TYPE	PHASE	VOLTAGE
2	3000	Moloney	TCB	3	7200-4160/2400
2	3000	G.E.	OA-T	3	26,400-4160/2400
3	100	G.E.	Pyranol	1	2400/4160-240/480
2	1000	Mel.		3	13800-4000/2300
2	500	G.E.	K.S.T.Q.	1	4150-2406
1	300	Penna.	OA Askarel	3	12,470Y/7200-240
3	200	Amer.	C.C.	1	4160/7200-240/480
3	200	G.E.	HS-W2S	1	2400/4160-240/480
3	75	G.E.	H-form KF	1	2400/4160Y-120/240
1	75	West.	DS Dry	3	480/240-240/120
3	50	Niagara	Dry-air	1	2400/4160Y-120/240
3	50	Harrison	Dry-air	1	2400/4160Y-220/440

MOTOR GEN. SETS

QU.	KW	MAKE	SPEED	D.C.	A.C.
1	1000	West.	720	600	2300/4160 S.R.
1	400	West.	900	250	3 unit 4160 V. syn.
1	300	G.E.	1200	250	2300/4160 syn.
1	300	Al. Ch.	1200	125/250	3 unit 440 syn.
1	175	West.	1200	125	4160 syn.
1	100	West.	900	250	4160 syn.
1	45	G.E.	1170	30	440V Sq. Cage
1	300	West SK	900	250	syn. 480 volts

D.C. MOTORS—230 VOLT

QU.	HP	MAKE	SPEED	TYPE
1	350	G.E.	1200	ped. type
1	90	G.E.	1750	CDM
1	30	West.	1750	SK-113
1	30	G.E.	2300	CD-85
1	15	Crocker Wh.	1750	CCM, TEFC

SLIP RING MOTORS

QU.	HP	MAKE	SPEED	TYPE	VOLTS
1	500	G.E.	450	MT-423Y	2300
1	450	West.	1800	CW 4-30-9	220
1	350	West.	1800	CW	2300
1	200	West.	585	CW	440
8	150	Al. Ch.	1760	AY-RW	2300
3	150	G.E.	590	1-16	4000
1	100	West.	1770	TEFC B.B.	220/440
1	75	West.	1160	CW 607	220/440
1	75	West.	600	CW 774C	220
1	50	G.E.	570	MT 552	220/440

SQUIRREL CAGE MOTORS—3 phase—60 cyc.

QU.	HP	MAKE	SPEED	TYPE	VOLTS
1	300	Al. Ch.	1200	TRW	2300
1	300	G.E.	1800	63368 B.B. Drip	4160/2400
1	275	G.E.	1180	KT 559B8	2300
1	75	G.E.	1790	KTEFC B.B.	2300
1	75	Cont.	1780	K 6325-8 XP B.B.	440
3	100	Cont.	3570	NP 585-8 XP B.B.	440
2	250	G.E.	3565	NP5058X XP B.B.	440
2	150	G.E.	875	KT 552Y	440
1	60	G.E.	3530	KF 405Y Vert.	220/440
1	50	Cont.	3530	NP 445X XP B.B.	220/440

MOTORS—SYNCHRONOUS 3 ph, 60 cyc.

HP	SPEED	MAKE	TYPE	VOLTS
325	900	West.		2300
400	450	West.	HR	440
300	720	El. Mh. TEFC		2300
200/100	720/360	West.		4150
150	3600	G.E.	TS 956Y drip	2300
150	1800	G.E.	TS	220/440
150	900	West.		220/440
125	900	G.E.	TS 7536	2300
125	600	G.E.	TS 7641	2300
75	1200	Cr. Wh.	ALT B.B.	220/440

FOR POWER
J.L. HEMPHILL & CO.
1602 54th STREET, NORTH BERGEN, N. J.
PHONE NEW YORK LONGACRE 5-3227
PHONE NEW JERSEY UNION 3-2700

Circle 510 on Reader Service Card

7 B&W WATERTUBE BOILERS

From the unfinished Battle Cruiser "Hawaii"

157,000 lbs./hour
—600 lbs.—850°—
oil - fired boilers
with all accessories. New.

FOR IMMEDIATE DELIVERY

THE BOSTON METALS CO.

313 E. Baltimore St., Baltimore 2, Md.
ELGIN 5-5050 LEXINGTON 9-1900

Circle 512 on Reader Service Card

LIKE NEW A.C. DIESEL GENERATORS

2— 300 K.W.—GM 8-268A, West. 450 V.
2— 350 K.W.—Worthington—GM, 2300 V.
1— 435 K.W.—4 GM 6-71 West., 2300 V.
1— 750 K.W.—GM 12-278A West. 440 V. UNUSED
2—1000 K.W.—GM 16278A Elliot 2300/4160 V.

NON-CONDENSING A.C. TURBINE GENERATORS

500 K.W.— 460 V—G.E. 265#/17#
750 K.W.—4600 V—G.E. 190#/10#
3500 K.W.— 600 V—G.E. 450#/double extraction

Also condensing units of all sizes and high pressure boilers.

CAPITAL EQUIPMENT CORP.
40 Walnut St., Newark 2, New Jersey
MA 2-5222

Circle 513 on Reader Service Card

POWER EQUIPMENT CO.

BARGAIN PRICES

ON NEW and GUARANTEED Rebuilt MOTORS!

Special purchase of the following 220 or 440 Volt—60 Cycle—3 phase—New Motors—in Crates—Inquire for Special Bargain Prices

Qty.	HP	Make	Type	Speed
1	300	Marathon. B.B. Drip	TDC-586	1800
1	300	Al. Chal. S.B. Drip	AW-26-J86	1800
2	200	U.S. B.B. Splash	SC-587	1800
3	200	Century S.B. Drip	SC-586	1800
3	200	Wagner. S.B. Drip	RPI-585	1800
3	150	Century S.B. Drip	SC-585	1800
4	150	Ideal S.B. Drip	A-584	1800
6	100	Reliance T.E.F.C.B.B.	AA-445U	1800
1	100	Al. Chal. T.E.F.C.B.B.-XP	AZZ-23E8	900
3	60	Ideal. B.B. Drip	A-504	1200
4	50	Marathon B.B. Splash	ZTDR-365U	1800
2	50	El. Dyn. T.E.F.C.B.B.	TN-444	1800
4	30	West T.E.F.C.B.B.	CS-326U	1800

Slip Ring Motors—220 or 440 Volt—60 Cycle—3 phase—Guaranteed Rebuilt

Qty.	HP	Make	Type	Speed
1	300	G.E.S.B. Open	IM	1200
1	300	G.E.S.B. Open	IM	900
1	300	West. S.B. Open	CW	600
1	250	G.E.S.B. Open	IM	600
1	300	West. S.S.B. Open	CW-871C	1800
1	200	G.E.S.B. Open	IM	1200
1	300	G.E.S.B. Open	IM	900
1	200	G.E.S.B. Open	IM	720
1	200	G.E.S.B. Drip	M	600
1	150	L.A.B.B. Splash	FH-118	1200
2	150	G.E.S.B. Open	IM	1200
1	150	G.E.S.B. Open	IM	900
1	150	G.E.S.B. Open	IM	720
1	150	G.E.S.B. Open	IM	600

Motor Generator Sets—Guaranteed Rebuilt

KW	Make	AC Motor	Speed
100	West—230 Volt—B.B.	220 or 440 Volt	1800
100	G.E.—230 Volt—B.B.	220 or 440 Volt	1800
60	C.W.—230 Volt—B.B.	220 or 440 Volt	1200
50	F.M.—230 Volt—B.B.	220 or 440 Volt	1800

Send for our FREE Catalog

Cash for your surplus new and used electric equipment. Send your list today.

Large line of motors, control equipment, AC & DC Generators, MG sets and transformers.

Phone or Wire Us Collect

POWER EQUIPMENT CO.
8 Cairn St., Rochester 2, N. Y.
P. O. Box 534 • Phone BE-5-1662

Circle 514 on Reader Service Card

BOILERS
HI PRESSURE

50 hp. Mund Scotch Marine package, oil, 125 psi, fully automatic, new, unused (7)
100 hp. Cycloth. package 125 psi., oil, automatic
150 hp. Cleaver Brooks package, 150 psi., oil, automatic
175 hp. Comb. Engr. package 375 psi., oil, automatic
200 hp. Cleaver Brooks, package, 125 psi, #601L, automatic, complete, (2)
500 hp. Cleaver Brooks, package, 150 psi., oil, automatic
300-600 hp. Bigelow Scotch Marine Boilers, 3,000 sq. ft., 200 psi, complete package units, automatic, etc. (1955) (3)
10,000 lbs/hr., B&W, package watertube, 2100 psi, oil, compl. (exc. for testing purposes)
45,000 lbs. B&W, 435 psi., packaged, oil, assembled, unused, ready to ship
45,000 lbs. C-Engr. 250 psi. 2 drum assembled, ready to ship
60,000 lbs. B&W, 475 psi., oil, packaged, assembled, unused, ready to ship
100,000 lbs./hr.—Riley, 200 psi, comb. oil-gas firing, Ron design
150,000 lbs/hr., C-Engr., 600 psig, 4 drum Stirling, 3" tubes, suprh., air prehr., compl. (3)
195,000 lbs, C Engr., 950 psi., 2 drum, stoker and oil, superheat, etc. Completely installed new 1954. All 2½" Tubes.

TURBO GENERATORS — OTHER POWER PLANT EQUIPMENT

complete listing catalogue sent upon request

USED—NEW—PURCHASED—SOLD—RENTED
Large and Complete Inventory for Domestic and Export

INDECK POWER EQUIPMENT CO.

9750 N. Skokie Blvd.—Skokie (Chicago), Illinois—OR 3-7666
Cable: Indeckpower—Skokie Illinois USA

Circle 518 on Reader Service Card

For Sale — New 1948

1—1500 KW G.E. Automatic Ext. Condensing 200/400# Ext. pressure 10#, 9 Stage Generator 3/60/480 volts. Directly con Exciter Switchboard, 2 pass condenser & all auxiliaries.

CHARLES WEAVER, INC.
19701 Jas. Couzens Hwy., Detroit 35, Mich.
Telephone BRoadway 3-1900
Cable: CHASWEAVER

Circle 515 on Reader Service Card

10—SUPLUS DUAL FUEL CYLINDER HEADS

Nordberg, 21½" bore, dual fuel engine. Also other surplus Diesel parts and equipment. Advise needs.

BOX FS-7266, POWER
645 N. Michigan Ave., Chicago 11, Ill.

Circle 516 on Reader Service Card

DIESEL ENGINE

1 HEAVY DUTY NORDBERG

Type T5M—model 32118—1700 HP @ 180 RPM — 21½" x 29". Unit complete with all pumps and coolers. Can be used for generator drive, producing 2400 HP @ 225 RPM. Equal to new. Presently in Maritime Academy.

THE BOSTON METALS CO.
313 E. Baltimore St., Baltimore 2, Md.
ELGIN 5-5050 — LEXINGTON 9-1900

Circle 517 on Reader Service Card

DIESEL GENERATOR SETS NEW OR REMANUFACTURED

A.C.—D.C.—Any Voltage

GENERAL MOTORS
1100 KW—16-278A
1000 KW—16-567C
800 KW—12-278A
750 KW—12-567A
750 KW—12-567C
500 KW— 8-278A
350 KW— 8-278A
300 KW— 8-268A
200 KW— 8-268A
100 KW— 3-268A

ALCO
1500 KW—Model 251
500 KW—Model 539

FAIRBANKS MORSE
1500 KW—33F16—10 cyl. 16"x20"
1136 KW—38D8⅛—10 cyl.
1000 KW—38D8⅛— 9 cyl.

BALDWIN-LIMA-HAMILTON
500 KW—600 Series—8 cyl. 12¾"x15"

ENTERPRISE
400 KW—DSG6—6 cyl. 12½"x15"—514 RPM
300 KW—DSG6—6 cyl. 12½"x15"—450 RPM

A. G. Schoonmaker Co., Inc.

Established 1898
Dept. C, Foot Spring St., Sausalito, Calif.
Phone: EDgewater 2-1490
WRITE WIRE PHONE

Circle 519 on Reader Service Card

ELECTRICAL POWER EQUIPMENT

SLIP RING MOTORS

HP	RPM	MAKE	VOLTS	TYPE
2500	257	G.E.	6600	MT-28
1000	1200	Al.-Ch.	4000	ANY
1000	900	Al.-Ch.	2300	ANY
700	720	G.E.	440	I-M
600	1800	G.E.	4160	M-6345
500	1200	G.E.	440	M-6345Z
400	1200	West.	2300	CW
400	720	G.E.	440	MT-573Y
350	1800	Al.-Ch.	2300	ARTW
300	900	G.E.	440	IM-17
300	450	G.E.	440	IM-16
250	600	West.	2300	CW-1000
200	514	West.	2300	CW-950A

MOTOR GENERATOR SETS

KW	MAKE	A.C.V.	D.C.V.
1750	G.E.	4160/2300	250/300
1250	West.	4160/2300	250
1000	West.	4160/2300	250
750	G.E.	4160/2300	250
600	G.E. (3 unit)	2300/440	125/250
500	G.E.	2300	250
400	Al.-Ch.	2300/440	125/250
250	G.E.	2300	250
200	G.E.	2300	250
150	West.	440	250

D. C. MOTORS

HP	RPM	MAKE	VOLTS	TYPE
1500	300	West.	250	TEFV
850	250/500	West.	250	QM
600	250/500	G.E.	600	DBL. ARM.
500	210	G.E.	250	MCF
400	1150	REL.	250	T-1970
400	300/900	G.M. (2)	250	D4D
300	575/1150	West.	250	CB-500
200	700	West.	250	SK-201
150	230/1000	G.E.	250	MCF
150	1150	G.E. (2)	250	RC-37
150	400/530	West.	250	SK-201
100	400/800	G.E.	250	MPC-6
100	575	G.E.	250	CD-147

Write for current complete stock lists on electrical power equipment you need or send your list of surplus and used equipment for our offer.

Phone CAnal 6-2900

50 YEARS 1910 - 1960 SERVICE TO INDUSTRY

CHICAGO Electric Co.

Circle 520 on Reader Service Card

TURBO-GENERATORS
DIESELS

BOILERS

STEAM SPECIALTIES
PUMPS — FANS

• LARGE SELECTION — NEW AND USED

1. B. & W. Pack. Boiler, Oil	122,250#/Hr.	684 psi
2. B. & W. Pack. Boiler, Oil	60,000#/Hr.	475 psi
3. B. & W. Pack. Boiler, Oil	44,500#/Hr.	475 psi
4. B. & W. "FF" Boiler, Oil/Gas	35,000#/Hr.	450 psi
5. Springfield Str. Tube	60,000#/Hr.	250 psi
6. Comb. Eng. "VU"	85,000#/Hr.	300 psi
7. Foster Wheeler, Oil	30,000#/Hr.	250 psi
8. Wickes Type "A" Oil	18,000#/Hr.	150 psi
9. Erie Type "C"	45,000#/Hr.	100 psi
10. Comb. Eng. "M2" Oil	6,000#/Hr.	375 psi
11. Cl. Brooks Pack. Oil	250 HP	150 psi

WABASH POWER
•EXPORT•

• EXPERIENCED ENGINEERS TO ASSIST YOU

12. Cyclotherm Pack. Oil/Gas	100 HP	125 psi
13. Cyclotherm Pack. Oil	60 HP	150 psi
14. Cyclotherm Pack. Oil/Gas	150 HP	150 psi
15. Vapor Clarkson, Oil	165 HP	300 psi
16. H.R.T. Boilers	300 & 150 HP	125 psi
17. Erie City Economic	200/400 HP	125 psi

18. 600 KW, G.E. Turbo-Gen. N. Cond. 450 psi—3/60/480v./3600 RPM
19. 750 KW Wghse. Turbo-Gen. Cond. 250 psi—3/60/450v./1200 RPM
20. 1500 KW Wghse. Turbo-Gen. N.C. 190 psi—3/60/450v./3600 RPM
21. 1800 KW G.E. Turbo-Gen. Cond. 410 psi—3/60/1785v./3600 RPM
22. 4600 KW G.E. Turbo-Gen Cond. 410 psi—3/98.5/2700v./5700 RPM

WABASH POWER EQUIPMENT CO.
3300 W. PETERSON AVE., CHICAGO 45, ILL. TEL. IN 3-0303

Circle 521 on Reader Service Card

LIQUIDATING

TRANSFORMERS

3—2500 KVA Penna., 1Ø, 34,400-2400/4160Y.
1—1500 KVA G.E. substation, 13,200-480.
3—1000 KVA Uptegraff 1Ø 2400/4160Y-480.
3—1000 KVA G.E. 1Ø, 13,800-460.
3— 500 KVA Wagner, 1Ø, 66,000-460.
3— 500 KVA G.E., 1Ø, 7960/13,800-2400.
1— 300 KVA Stockwell, 3Ø, 2400-208/120.
1— 150 KVA, 3Ø, 2400-108Y/120.
15—75, 50, 15 KVA transformers.
2—I.T.E. Mutimite Circuit-Breakers.

BOILERS

2—520 HP Foster-Wheeler, 1100 psi, gas-oil.
5—435 HP Comb.-Eng., 300 psi, gas-oil.
2—200 HP Keeler, 160 psi, coal.
3—Kewanee Package boilers, 15 psi; 135, 30, 15 HP.
1—Lesler 40 HP package boiler, 1100 psi, gas-oil.
3—43 HP waste-heat boilers, 250 psi.

COMPRESSORS

2—Ing. Rand #PRC-4, 2600 cfm @ 1000 psi, 4-stage, complete, 1000 HP syn. motor.
3—Worthington #LTC-4, 3500 cfm @ 45 psi, 24 x 15, 500 HP gas drive.
1—Chi.-Pneu. #19-32-30-18x24, 3026 cfm @ 60 psi, steam driven.
2—Chi.-Pneu. #T-CB-3, 317 cfm @ 1500 psi, 3-stage, 11¼ x 7¼ x 3⅛ x 13, steam turbine drive.
2—Penna. #3ATC, 305 cfm @ 100 psi, 12 x 11, w/88 HP gas engine drive, or 125 HP motor.
1—Ing.-Rand #ES-3, 10½ x 7⅛ x 3⅛, 125 HP motor.
15—Ing.-Rand #67D9, type 30, 83 cfm, 6 x 6 x 5, 10 HP.
1—Ing.-Rand #ER-1, 67 cfm, 6 x 6, 10 HP.
1—York #Y-36, 12½ x 14½, Ammonia, steam drive.

PUMPS

2—6000 GPM @ 111', Warren, centrif., 12" x 12", 215 HP steam turbine.
2—3500 GPM @ 125', Ing.-Rand, centrif., 12" x 10", #10AFVS, 125 HP.
2—3500 GPM @ 80', Worthington, turbine, #16QHO-1, single stage, 100 HP.
1—2000 GPM @ 125', Ing.-Rand, centrif., 8" x 6", #6DMV, 100 HP.
2—1800 GPM @ 80' Worthington, turbine, #12QHO-2, 2-stage, 50 HP.
3—163.5 GPM @ 3380' Ing.-Rand, centrif., #2½VHTB-14, 250 HP.
3—DeLaval IMO rotary pumps.

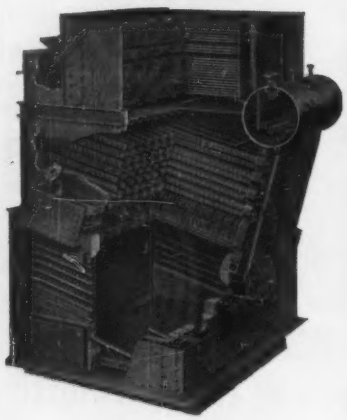
MISCELLANEOUS

20—Sharples #AS-16V super centrifugals. Inconel bowls, sludge disch.
1—B. & W. coal pulv., #32-E, 75 HP.
1—Raymond 66" hi-side roller mill.
1—Hough type NA payloader.
1—Gas Machinery 60" dia. rot. annealing furnace.
20—Steam turbine drives, up to 150 HP.
1—Graver deaerating feed-water heater.
2—15 KW motor-generator sets.
21—Hydrogen cylinders, 9⅝" x 21', 2150 psig.
1—Graver water demineralizing plant, complete.
1—Hydrogen reforming plant, 288,000 SCFD.

PERRY EQUIP. CORP.
1422 N. Sixth St.
Philadelphia 22, Pa.
POplar 3-3505

Circle 522 on Reader Service Card

B & W
MAIN BOILER UNITS



DESIGN DATA:

Pressures, lb. per sq. in. (normal power)	
Steam drum design	500
Steam drum operating	459
Superheater outlet operating	450
Temperatures, deg. F. (normal power)	
Superheated steam	750
Feedwater	318
Air heater gas outlet	340
Air to burners	350
Evaporation Rate, lb. per hr. actual	
(normal power)	26,500
(overload)	39,750
Draft Loss, in. w.g. (normal power), 15 per cent excess air, air inlet to gas outlet	2.3
Furnace Volume, cu. ft.	405
Heating Surfaces, sq. ft.	
Boiler and water walls	4,060
Superheater	640
Air heater	3,375
Weight, lb.	
Weight of one complete unit, dry	108,737

THE BOSTON METALS CO
313 E. Baltimore St., Baltimore 2, Md.
ELGIN 5-5050 — LEXINGTON 9-1900

Circle 523 on Reader Service Card

Buying
Good USED Equipment
is frequently the difference between having needed equipment or doing without it.

FOR SALE

1—2000 KW G.E. Turbine-Generator 400#—750° F Throttle, Automatic 150# and 85# Extraction, 10# Exhaust.

Generator is 2500 KVA, 3-60-480 volt, with exciter and accessories.

WANTED

2500-5000 KW Turbine-Generators 400-600# Throttle, 700-750° condensing or non-condensing.

Write to Joliet Equipment Corporation
Box 1078, Gross Street, Joliet, Ill.
Or Phone: Joliet SA 7-4738
Chicago BI 2-2458

Circle 524 on Reader Service Card

SEARCHLIGHT EQUIPMENT LOCATING SERVICE

No Charge or Obligation

This service is aimed at helping you, the reader of "SEARCHLIGHT", to locate Surplus new and used power equipment not currently advertised. (This service is for USER-BUYERS only).

How to use: Check the dealer ads to see if what you want is not currently advertised. If not, send us the specifications of the equipment wanted on the coupon below, or on your company letterhead to:

SEARCHLIGHT EQUIPMENT LOCATING SERVICE
c/o POWER
P.O. Box 12, N. Y. 36, N. Y.

Your requirements will be brought promptly to the attention of the equipment dealers advertising in this section. You will receive replies directly from them.

SEARCHLIGHT EQUIPMENT LOCATING SERVICE,
c/o Power,
P.O. Box 12, N.Y. 36, N.Y.

Please help us locate the following used equipment:

.....

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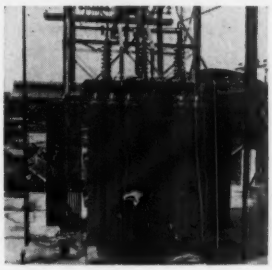
NAME .....

TITLE ..... COMPANY .....

STREET ..... CITY 12/61



(1) 7500 KVA WESTINGHOUSE TRANSFORMER—1949

Primary 69300/67650/66000/64350/62700 Volts—Secondary 13800 Volts, 3 Phase, 60 Cycle type—SL, Class OA, Imp 8.4%—S/N 4089566 complete with overhead structure, bushings, strain, insulators, fused disconnects, etc.

(1) 500 KW WESTINGHOUSE MOTOR GENERATOR SET

275 Volt, DC 1817 Ampere, driven by one 750 H.P. synchronous motor, 2300 volt, 60 cycle, 3 phase. Complete with switch gear.

(1) 1250 KW GENERAL ELECTRIC MOTOR GENERATOR SET

270 volt DC, 4625 Amperes. Driven by 1750 H.P. synchronous motor, 2300 volt, 60 cycle, 3 phase. Complete with switch gear.

Liquidating former Phoenix Steel Corp. Plant at Harrisburg, Pa. Dozens of other transformers 2400 Volt Primary 220/440 secondary 60 Cycle—666 KVA to 25 KVA.

AT FRACTION OF REPLACEMENT PRICE

WRITE — PHONE — WIRE

LIPSETT DIVISION
Luria Brothers & Company, Inc.
915 South Front Street
P.O. Box 1151
Harrisburg, Pa.

CEDAR 6-5988

Arnold L. Landesberg—Project Manager

Circle 526 on Reader Service Card

12000 CFM
NEW VANEAXIAL FLOW
FANS

Sturdevant A-12, 3" Static Pressure 2 Speed Westinghouse AC Waterproof Motor, HP 10-3, 3 Phase 60 Cycle 440 Volts, Complete with Magnetic Controller and Spares, F.O.B. Trenton, N.J. and Ogden, Utah.

$450.00 EACH

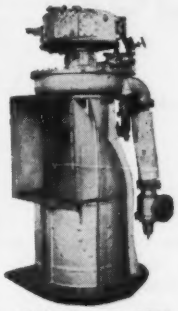
(Replacement Cost $2000.00)

EASTERN SCRAP AND SALVAGE CORPORATION
65 MUIRHEAD AVE., TRENTON, N.J.
OW 5-6351

Circle 527 on Reader Service Card

20 TURBINE DRIVEN FORCED DRAFT BLOWERS

mfg. by B. F. Sturtevant Co.



PRICED TO SELL
$950.00 EACH

With turbine throttle pressure of 575# dry saturated steam and 15# back pressure, the following performance table applies:

CFM	STATIC PRESSURE	RPM	H.P.	LBS./HOUR
29,500	35"	5540	250	8250
22,500	21.50"	4280	117	3978
19,350	14.80"	3600	69	2829
22,100	8.80"	3385	57	2508
21,000	7.75"	3220	48	2208
14,750	8.95"	2780	32	1760
14,000	8.05"	2640	27	1620
15,000	4.00"	2310	18	1260

The blowers will deliver heir rated capacity at 460# dry saturated steam and 15# back pressure. Units are vertical, with 30¼" alloy steel propeller fan. V-C-7 turbine—built to high Navy standards. Each wheel is machined from a single forging with the buckets milled into the rim. Spare parts furnished with each fan.

The BOSTON METALS Co.
313 East Baltimore Street, Baltimore 2, Maryland
CURTIS 7-5050 LEXINGTON 9-1900

Circle 528 on Reader Service Card

TRANSFORMERS

BOUGHT · SOLD · RENTED
REWOUND · RE-DESIGNED
MANUFACTURED

Ask for our Stock List

3—2500 KVA G-E 69000—2400/4160Y
3—2500 KVA G-E 69000—7200/12470Y
3—1500 KVA G-E 6900—2400/4160Y
3—1500 KVA G-E 69000—7200/12470Y
3—1000 KVA G-E 34500—7200/12470Y
3— 833 KVA W-H 43800—480
3— 667 KVA G-E 13200—2400/4160Y
3— 500 KVA A-Ch. 2400/4160Y—240x480
3— 500 KVA A-Ch. 7200/12470Y—240x480
3— 500 KVA A-Ch. 13200—240x480
3— 500 KVA A-Ch. 13800—240x480

THE ELECTRIC SERVICE CO., 5322 Hetzel St., Cincinnati 27, Ohio
"America's Exclusive Independent Transformer Service Shop"

Circle 529 on Reader Service Card

COMPRESSORS

No better values at any price

72 CFM 1500 PSI 6¼-3⅜-1⅜x7 CP
80 CFM 3500 PSI 6⅜-4-1 7/16x9 IR ES8
138 CFM 100 PSI 7x7, Ing. ES. CP & Joy
258 CFM 500 PSI 9½x4¼x11 Ing. ES2 New
288 CFM 100 PSI 9x9 Ing. Worth. CP
306 CFM 100 PSI 9x7 Joy WG9
311 CFM 1500 PSI 10½x7⅛-3⅛-13 IR-ES8
465 CFM 100 PSI 12x11-IR-ES CP.T. Worth HB
502 CFM 125 PSI 12x13 Worth HB
676 CFM 110 PSI 15-9¼x12 Ing. XRE
686 CFM 100 PSI 14x13 Ing. ES
1065 CFM 110 PSI 18-12x14 Ing. Rand XRE 175 HP Syn 3-60-440
1650 CFM (actual) 100 PSI Fuller C800—300 HP with 300HP Syn 3-60-440 .8 PF
2200 CFM 100 PSI 26-15x28 Ch. Pn. 000 350-HP 3-6-4160-4600 .8 PF
2230 CFM 110 PSI 25-15x12 Ing. Rand XVH 350 HP Syn 3-60-440

AMERICAN AIR COMPRESSOR CORP.
48th & P, North Bergen, N.J. UNion 5-1397

Circle 530 on Reader Service Card

For Sale — New 1951

1—500 KW DeLaval-Elec. Mach. Generator 400/600# 750°, non-condensing 150/200#. Complete with Exciter & Switchgear. Generator 3/60/240/480 volts. Unit in excellent condition.

CHARLES WEAVER, INC.
19701 Jas. Couzens Hwy., Detroit 35, Mich.
Telephone BRoadway 3-1900
Cable: CHASWEAVER

Circle 531 on Reader Service Card

STOKER REPLACEMENT PARTS
For
WESTINGHOUSE-TAYLOR
And
Many Others — Satisfaction Guaranteed

MONUMENTAL STOKER SERVICE, INC.
OLD MONTGOMERY ROAD, ROUTE 1
ELLICOTT CITY, MD.

Circle 532 on Reader Service Card

STEAM TURBINE GENERATORS

G.E. 2250 KVA—3600 RPM—2400 V—remove exciter—motor generator unit—rated at 30 H.P. 3Ø—440 V—generator—20 KW—125 V shunt wound—G.E. Turbine 400 lbs. straight condensing—non-extracting—complete auxiliary equipment optional.

G.E. 375 KVA—2400 V—Turbine speed 4300 RPM generator speed 1200 RPM. Direct connected exciter—G.E. Turbine 400# non-condensing with field rheostat—condensate pump & gen. control panel less breaker.

A-C 1875 KVA—3600 RPM—2400 V—direct connected exciter—A-C Turbine—400#—condensing & extracting at 150#—can also extract at 75 and 5 lb. pressure—complete w/ field rheostat—condensate pumps—throttle valve and conrol panel.

All units in operating condition and are available for inspection.

For Complete Information Write or Phone:

W. A. BEFFEL—Plant Engineer
J. I. CASE CO.—Clausen Works
Racine, Wis.—Melrose 4-6611

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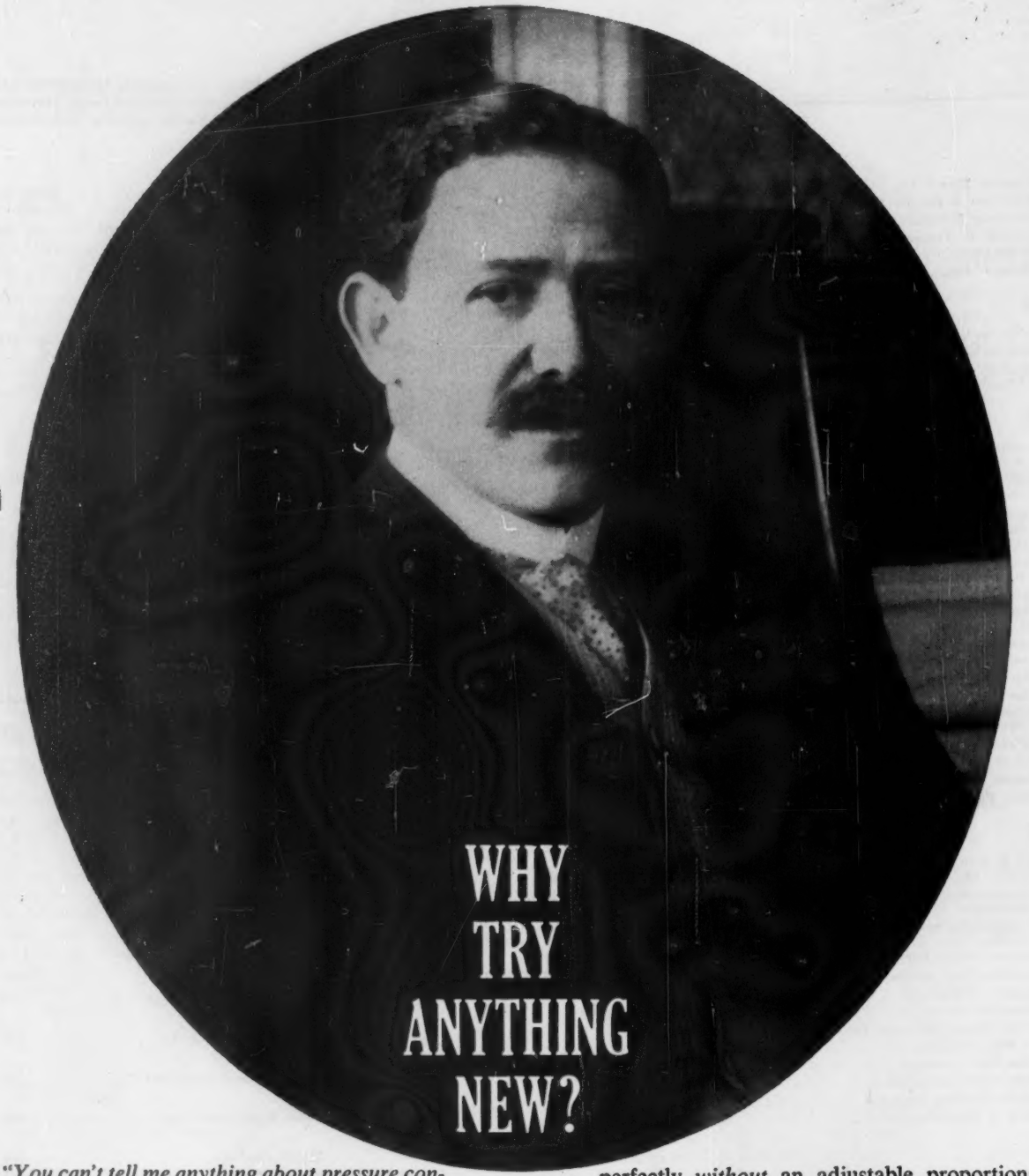


WHY TRY ANYTHING NEW?

"You can't tell me anything about pressure controllers. To claim that you can have stability without being plagued by a black box full of bourdon tubes, flapper-nozzles and reset contrivances is nonsense . . . plain nonsense!"

We disagree! It seems that in the bulk of pressure control systems with short lag factors, the adjustable proportional band and reset mechanisms serve chiefly as crutches. They do little more than compensate for a flapper valve's over-sensitivity to minor system disturbances. In this respect, they merely approach, without equalling, the *inherent* operating stability of the Leslie Control Pilot's forward design. (No flappers, no problems). This pilot functions perfectly *without* an adjustable proportional band in such systems.

There are instances, however, where it is prudent to specify an adjustable proportional band for a broader range of applicability. Here, your answer is a Leslie pressure pilot with a single knob proportional band adjustment. Used either as a controller or a transmitter, this combination is the leader among pressure pilots. Write today for details on fixed or adjustable proportional band Leslie Control Pilots, or both.

LESLIE REGULATORS AND CONTROLLERS

A SINGLE STANDARD OF QUALITY SINCE 1900

Leslie Co., 701 Grant Avenue, Lyndhurst, New Jersey

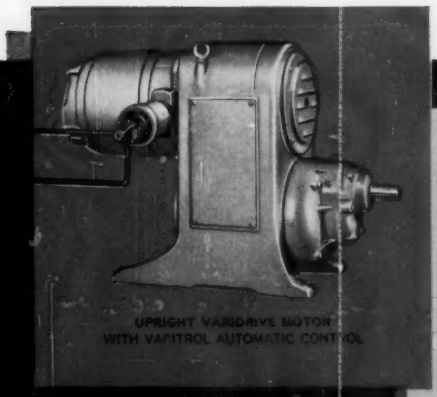
For more facts circle 323 on Reader Service card, p 117

Circle 202 on Reader Service card for this ad ➤

10,000 CONFIGURATIONS— EACH WITH 10,000 SPEEDS!

Choose from thousands of different shapes, sizes, attitudes, mountings, horsepowers, enclosures, ungeared or geared combinations—choose the U.S. VARIDRIVE MOTOR that exactly fits your application! U.S. introduced the *first* self-contained a.c. motorized variable speed drive for industry —in 1932! Ever since, U.S. design engineers have been developing new Varidrives to combine new characteristics... new controls, too: Manual, mechanical, electrical remote control, and automatic control. Ratings available: **¼ to 75 h.p.** *(Send for free 16-page color Varidrive Bulletin, No. F-1797.)* For your variable speed application, specify:

U.S. VARIDRIVE motors



UPRIGHT VARIDRIVE MOTOR WITH VARITROL AUTOMATIC CONTROL

VARIDRIVE
WITH INTEGRAL GEARING, MOTOR AND TAKE-OFF SHAFT SAME SIDE

SMALLEST VARIDRIVE
1/4 TO 1 H.P.
WITH HAND CONTROL ASSEMBLY

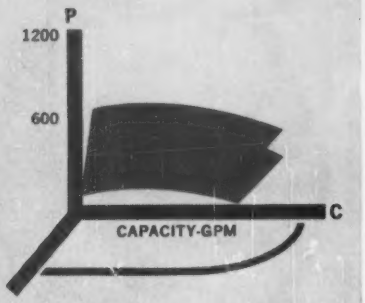
MOTOMOUNT VARIDRIVE
WITH STANDARD FOOT-MOUNTED MOTOR

VARIDRIVE MOTOR WITH INTEGRAL RIGHT-ANGLE WORM-GEARING

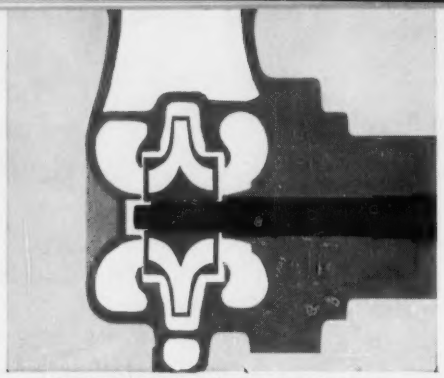
HORIZONTAL VARIDRIVE MOTOR

U.S. ELECTRICAL MOTORS INC.

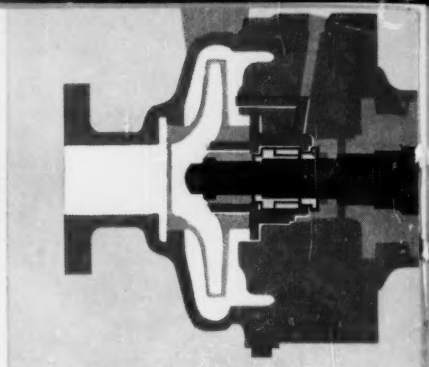
P.O. Box 2058, Los Angeles, California or Milford, Connecticut



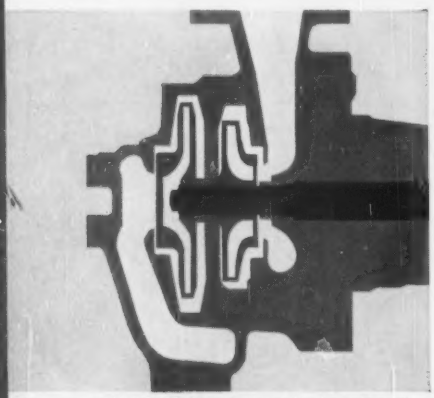
PERFORMANCE. Better working and test pressure limits—compare them!



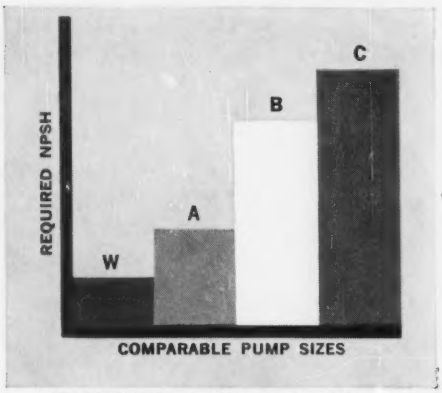
PERFORMANCE. Best with balanced double suction impellers for higher capacities.



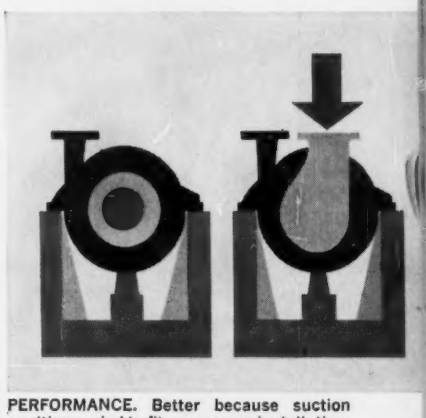
LIFE. Longer because of best internal liquid flow arrangement for flushing seal.



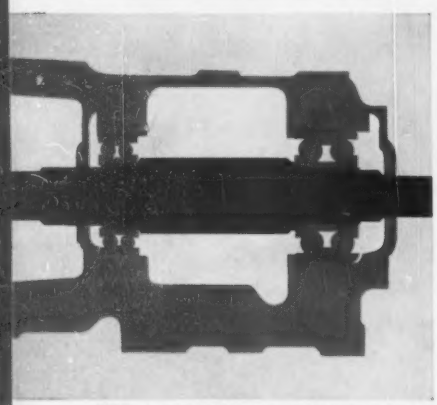
PERFORMANCE. Best with two-stage impeller design handling the higher heads.



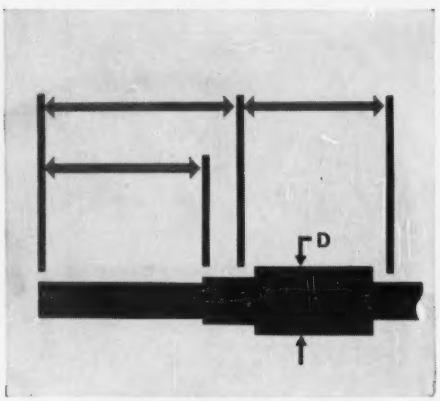
PERFORMANCE. Better because minimum practical NPSH required (validated by test.)



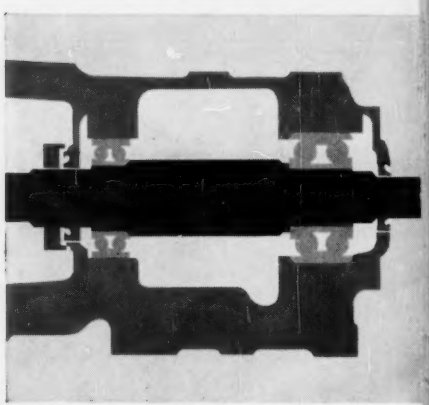
PERFORMANCE. Better because suction position varied to fit your pump installation.



LIFE. Longest because model for model, no heavier shaft bearings are available.



LIFE. Longer because shaft proportions are heavier, second to none. Analyze them!



LIFE. Longer because bearing housing seals and slingers prevent contamination.

For process work and high temperature water applications...

PUMP WITH EXCLUSIVE FEATURE PACKAGE

These are some—not all—of the important features of the Worthington HN process pump line. These features form an exclusive group that we know packs more value into the price than any comparable process pump.

One competitive pump may have one or more of these features. Another may have others. But no other pump line offers them all.

Judge this line for performance—working temperatures and pressures are unsurpassed. Judge this line for long life—its construction features add up to the most dependable design and its corrosion allowances are the best in any pressure range. Judge this line for versatility—its materials and construction variations are economical for use throughout your plant.

Frankly, we'd like you to examine in complete detail the exclusive feature package that we offer in this HN process pump line. Its current design and quality control techniques are dictated specifically by our long experience in the process industries.

Better yet, let us quote this line so you can see its complete value in a competitive light. Please contact your nearest Worthington District Office, or write Worthington Corporation, Dept. 21-8, Harrison, N. J. In Canada, Worthington (Canada) Ltd., Brantford, Ontario.

WORTHINGTON

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